Evaluation of Cognitive Improvements using Technological and Text-based Skills Training Tools

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Declaration

I hereby certify that the material, which I now submit for assessment on the programme of study leading to the award of a Master of Science (Research), is entirely my own work and has not been taken from the work of others except to the extent that such work has been cited and acknowledged within the text of my own work. No portion of the work contained in this thesis has been submitted in support of an application for another degree or qualification to this or any other institution.

Kevin Power — 16/06/2011

Signature of Candidate — Date

I hereby certify that all the unreferenced work described in this thesis and submitted for the award of a Master of Science (Research), is entirely the work of Kevin Power. No portion of the work contained in this thesis has been submitted in support of an application for another degree or qualification to this or any other institution.

16/06/2011

Signature of Supervisors — Date

Dr Marian Palmer — 16/6/2011

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Table of Contents

Table of Figures

List of Tables

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Cognitive skills improvements using text and technology based training tools

Kevin Power

Abstract

Recent research has indicated that use of cognitive skills training tools can produce positive benefits with older adults. However, little has been done to date comparing the efficacy of technologically based interventions (such as "Dr Kawashima's *Brain Training*" for the Nintendo DS Lite console) and more traditional, text-based interventions which are also available (for example Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*"), nor has it been determined which method older people derive most satisfaction from.

This study aimed to investigate cognitive skills improvements experienced by 40 older adults and 27 students using cognitive skills training tools. A Solomon 4 group design was employed to determine which intervention demonstrated the greatest improvements among older adults. A separate between groups study was conducted with 27 third level students who also received the cognitive skills training. Participants were asked to use either tool for 5-10 minutes per day. Pre and post-tests consisted of a measure of numerical ability, memory (MAC-S) and intelligence (WASI or Raven's SPM). Following training older adults indicated significant improvements on numerical ability and verbal intelligence regardless of intervention type. Following training students indicated a significant improvement on numerical ability and a partial improvement in memory regardless of intervention type. Focus groups were completed to investigate the high drop-out rate among older adults and attitudes towards the *Brain Training* tools. Results from focus groups indicated a preference for the technological intervention. This research provides a critical appraisal of the *Brain Training* tools and can help point the way for future improvements in the area. *Brain Training* improvements could lead to improved quality of life, and perhaps have financial and independent living ramifications for older adults. Despite numerical ability improvements the overall benefit to younger users is unclear.

Summary

Recent research has indicated that use of cognitive skills training tools can produce positive benefits with older adults. This study aimed to investigate cognitive skills improvements experienced by 40 older adults and 27 third level students using commercially available cognitive skills training tools. Participants were either asked to use the technologically based intervention "Dr Kawashima's *Brain Training*" for the Nintendo DS Lite console or the text-based intervention Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Pre and post tests consisted of a measure of numerical ability, memory (MAC-S) and intelligence (WASI/Raven's SPM). Following training older adults indicated significant improvements on numerical ability and verbal intelligence regardless of intervention type. Following training students indicated a significant improvement on numerical ability and a partial memory improvement, regardless of intervention type. Focus groups were conducted to investigate the high drop-out rate among older adults and attitudes towards the *Brain Training* tools. Focus group results indicated a preference for the technological intervention. This research provides a critical appraisal of *Brain Training* tools and can help point the way for future improvements in the area. Further research is needed to investigate the effects of cognitive skills training on memory and general cognitive functioning.

Chapter 1

Introduction

1.1 Overview

In the literature to date there has been considerable research into the general areas of both gerontology and cognitive skills training, with particular focus on how increased intellectual activity has been linked with a reduced risk of Alzheimer's disease. Studies have indicated that intellectually, active adults who read books, take classes, travel, attend cultural events and participate in clubs or other groups appear to do better into later life (Willis & Schaie, 1986). Contrastingly more isolated and inactive adults (despite levels of educational attainment) show the most decline in IQ (Bjorklund & Bee, 2009). Longitudinal studies have indicated that reducing the onset of cognitive decline is aided by demanding job environments and life spouses with high levels of cognitive functioning (Bjorklund & Bee, 2009). Bjorklund and Bee (2009) report that individuals who exercise cognitive processes through activities like playing chess, bridge or doing crossword puzzles can help to preserve these cognitive processes. These facets of the link between intellectual activity and improved cognitive functioning will be discussed in greater depth throughout the introduction and literature review.

1.1.2 What is *Brain Training*?

Various materials have been made available to the general public in order to improve cognitive abilities, including console games such as '*Brain Training*' (Nintendo, 2006a) and books such as "*Train Your Brain: 60 Days to a Better Brain*" (Kawashima, 2007). Both of these resources have been developed by Prof. Ryuta Kawashima, professor of neuroscience and head of the Functional Brain Imaging Centre at Tohoku University. Glenn Rees, the National Executive Director of Alzheimer's Australia, has applauded Kawashima's Nintendo DS Lite game, saying that "Nintendo's *Brain Training* is more than a game - it's a contribution to brain health" (Rees, nd, as cited by Nintendo, 2006b).

Owen et al (2010) describe *Brain Training* as aiming to improve cognitive functioning by regular use of computerized tests. Both *Brain Training* interventions mentioned endeavour to activate the pre frontal cortex. The prefrontal region comprising a large part of the frontal lobe controls creativity, memory, attentional processing, emotional processing, judgment, decision making and the detection of errors (Banich, 2004). According

to Kawashima (2007) the exercises used in the book and game increase the delivery of oxygen, blood and amino acids to the prefrontal cortex resulting in more neurons and neural connections, characteristic of a healthy brain. Dr Kawashima's *Brain Training* involves games that endeavour to ask users to read aloud and to solve arithmetic problems. The cognitive processes involved in reading aloud include recognition of visually presented words, conversion to phonological representation of words, analysis of learning of words and control of pronunciation. On comprehension of long or syntactically complex sentences older adults in particular show bilateral activation of an associated network of brain regions that support working memory (Wingfield & Grossman, 2006). The cognitive processes involved in solving arithmetic problems include recognition of visually presented numbers, arithmetic operations and control of hand movements. Solving simple problems also activate the bilateral prefrontal cortices. Kawashima's *Brain Training* works on the theory that both reading aloud and solving arithmetic problems require working memory, and this prefrontal stimulation may lead to positive transfer to other cognitive functions.

However, little has been done to date comparing the efficiency and effectiveness of technologically based interventions (such as "Dr Kawashima's *Brain Training*" for the Nintendo DS Lite console) and more traditional, text-based interventions which are generally available (for example Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*"), nor has it been determined which method older people derive most satisfaction from. This research aims to address this gap in the scientific literature, and as such will add significantly to the body of knowledge in this area.

Claims made by manufacturers of *Brain Training* tools indicate that cognition can be improved. The Dr Kawashima's *Brain Training*: How Old Is Your Brain Instruction manual (Nintendo, 2006) suggests that "training can help boost your memory" (p.5). According to Kawashima (2007) *Brain Training* can "help people retain mental clarity and stave off the mental effects of aging" (p.3) and obtain increased cognitive functioning or a better memory. The current study aims to investigate these claims in order to assess the efficacy of *Brain Training*. As will be discussed in the literature review the older population is increasing, tools that can improve cognition or reduce the effects of age related cognitive decline could be of particular benefit to older people.

1.1.3 Structure of Dissertation

Section 1.2 presents the literature review. The literature review intends to give an overview of ageing trends, costs of elderly care, the digital divide, cognitive health dementia and Alzheimer's, The Seattle Longitudinal Study of Ageing and The Baltimore Longitudinal Study of Aging. Furthermore intelligence, the cognitive reserve, cognitive and neural plasticity, assistive technology systems, the ACTIVE trial, the scientific basis for *Brain Training*, the transfer of cognitive training benefits to other cognitive functions, computerized cognitive training and adherence to cognitive training will be investigated. The literature review ends with the presentation of the research questions and hypotheses followed by a conclusion.

Chapter Two, entitled "A Study of Older Adults using Text-Based and Technology Based Skills Training Tools" describes the design employed to investigate older adult using text-based and technology based skills training tools. The methodology and results are then presented. Finally the discussion interprets the findings in relation to previous literature.

Chapter Three, entitled "A Study of Third Level Students using Text-Based and Technology Based Skills Training Tools" describes the design employed to investigate third level students using text-based and technology based skills training tools. The methodology and results are presented. Finally the discussion interprets the findings in relation to previous literature.

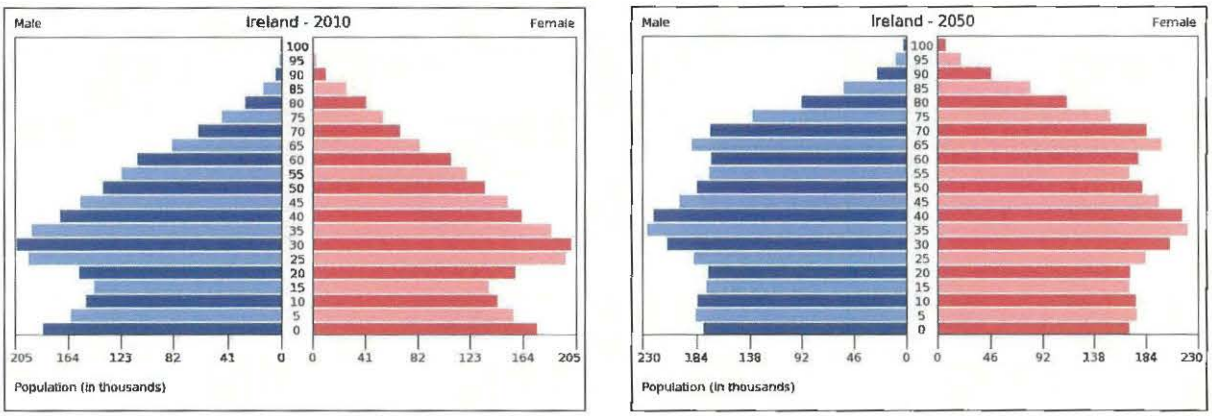
Chapter Four, entitled "Focus Groups and Interviews" examines participants' attitudes toward the cognitive skills training tools. The design and methodology employed to carry out focus groups and interviews with student and older adult participants are presented. The results are presented and the findings are discussed in relation to previous research.

The final Discussion Chapter, (Chapter Five) begins with a discussion of the general research questions. This is followed by a discussion of the hypotheses in relation to the findings from Chapters Two, Three and Four, with the view of drawing common conclusions between these individual studies and the previous literature. Furthermore Chapter Five describes the overall strengths and limitations of the research, implications of the research and lastly recommendations for future *Brain Training* devices and research are suggested.

1.2 Literature Review

1.2.1 Ageing Trends

According to the Central Statistics Office (2008) 11% of the Irish population was over 65 years of age in 2006. This proportion of the population has remained constant for the past 40 years. By the year 2011 it is estimated that persons aged 65 and over will represent 14.1 per cent of the Republic of Ireland's population. By 2041 there is estimated to be between 1.3 and 1.4 million old persons (those aged 65 years and over) compared with 460,000 in 2006. This suggests that by 2041, 20-25% of the Irish Population will be aged 65 years and over. Currently approximately 3% of the Irish population is over 80 years of age, this figure is expected to have more than trebled by 2036 (CSO, 2008). This is the fastest growing segment of the older population. These statistics present a population that is getting older. The transformation of population age groups will be profound and pervasive on our global society in the future. According to The Irish Longitudinal Study on Ageing (TILDA) by 2050 one in five persons will be aged over 60 compared to one out of every ten persons in 1993 (Kenny et al., 2010). See Figure 1.1 for Population Pyramids predicating the aging trend in Ireland (US Census Bureau, 2005).



Source: US Census Bureau

Figure 1.1: Population Pyramids Projecting Age Change Between the Years 2010 and 2050

This aging trend is expected to be observed across Europe, with older adults accounting for almost 35% of the population by 2050 (US Census Bureau, 2005). This presents a number of difficult challenges for society namely how to maintain an adequate standard of living and quality of life for older people, providing adequate services and

facilities such as health care and social care. Policy makers in Ireland have recognized the importance of the growing population trend setting up the Irish National Social Inclusion Strategy including older people as one of its key groups.

1.2.2 Costs of Elderly Health Care and Institutionalization

Estimates suggest that there will be a 60% rise in the cost of nursing homes and home help for the elderly over the next decade (Nationwide Health Solutions, 2010). Currently grants are available towards the cost of private nursing home care. However, due to means testing the majority of people earn too much money to qualify for these grant schemes. If projections for the future are accurate there could be a significantly increased older population without the aid of younger people to help them cope with the challenges of everyday living. With the future rise in elderly populations and the increased cost of elderly health care, staving off the effects of cognitive decline could be important for both financial and health reasons.

1.2.3 Digital Divide

In relation to Information and Communications Technology (ICT) usage among older people the Survey of Older People and ICTs in Ireland 2008 (Work Research Centre & Age Action Ireland, 2009) contributes many results of interest. The report claims that there is a digital divide in Ireland. The digital divide is comprised of an age divide which can be further broken down in relation to socioeconomic factors. The age divide is described as the likelihood of younger people to use Information and Communications Technology (ICT) in greater numbers as compared to older people. Table 1.1 describes Irish computers and internet usage rates in 2007 (Work Research Centre and Age Action Ireland, 2009).

Table 1.1: Internet and Computer Usage According to Age

Age (years)	Percentage Internet	Computer use
16 - 49	61.8	57.5
50 - 64	37.9	31.7
65 - 74	18.0	14.3

These figures show the relatively low levels of usage amongst those over 50 years, with the drop off especially high amongst the older old (65 to 74 years). Characteristic of the digital divide is the lower rates of usage among certain segments of the older population. In particular, less well educated older people are less likely to use computers or the internet and this segment comprise the majority of non users.

The digital divide is comprised largely of age related factors and socio-demographic factors. People over 65 are less likely to use the internet for practically useful purposes such as booking tickets, internet banking or paying tax or insurance. Secondly lack of ICT use can be traced to lower education levels; those with higher educational attainment make substantially wider use of the potential of the internet. The survey results also show a lack of interest among older users concerning ICTs. The survey reports that older users have negative attitudes, feeling too old to learn and feeling that ICTs and the internet are of no practical use to them. Perceived and actual affordability issues are a concern for a considerable minority of the older old. The oldest old participate less in computer and internet courses. Moreover men tend to participate less in computer and internet courses. The survey suggests that inclusion initiatives need to address the attitudes and motives in order to demonstrate the practical benefits of ICTs to older users.

The survey found the likelihood of being a computer non user in the over 65 category was 69.9%. The likelihood of being an internet non user was more than 78.2%. A strong association of education with the likelihood of non usage was found. Non usage was found to be considerably higher amongst those with lower levels of educational attainment. A similar association was observed with mobile phone usage. Among those aged over 65 years one in five were non users of mobile phones. Again a strong association with educational attainment was found, with likelihood of non usage being higher as levels of education decrease.

The CSO (2009) survey on information and communications technology presents statistics on how ICTs are being used in Ireland indicating a contrast between older and younger users. Over 92% of persons aged 16 to 24 have used a computer, while 31% of those aged 65 to 74 indicated they had used a computer. Persons in the 16 to 24 age group displayed the highest levels of computer and internet use.

1.2.5 Cognitive Health

Taken with physical decline, decline in cognitive abilities is a hallmark of ageing and predictive of mortality. Schaie and Hertzog (1983) demonstrated that age-related decline in these abilities is substantial once the sixties are reached. This may be a serious problem for Irish society, which is becoming increasingly older. Declines in cognitive function over the adult life span have been found in both cross-sectional and longitudinal studies for a variety of tasks, abilities, and processes (Kramer & Willis, 2002). Ofstedal et al (2005) suggested that independence in later life is as much determined by mental ability as by physical ability. From middle to older age a broad spectrum of cognitive health exists with maintained functioning at one extreme and dementia at the other (Kenny et al., 2010). A person in good cognitive health could be described as able to perform the simple activities of daily living such as dressing and bathing in addition to the more complex tasks such as managing money, paying bills and remembering to take medication. Decline in cognitive abilities may be an increasing problem for Irish society, which is becoming progressively older.

1.2.6 Dementia and Alzheimer's

Dementia is an overarching term used to describe a myriad of symptoms including; decline in memory, reasoning, and communication skills and an ongoing loss of the skills needed to carry out daily activities (The Alzheimer's Society of Ireland, 2007). Dementia is one of the main causes of disability later in life contributing 11.2 % of all years lived with disability among people over 60 years. Currently there are almost 40,000 people living with dementia in Ireland. Taking into account the rising aging population by 2036 this figure is predicted to rise to 103,998 people. In 2006 the base line cost of dementia in Ireland was estimated at €400m (The Alzheimer's Society of Ireland, 2007). Among over sixty-fives the fifth leading cause of death is Alzheimer's disease. This progressive, incurable deterioration of key areas of the brain can be said to be truly a disease of old age as 90% of the cases develop after the age of 65 (Bjorklund & Bee, 2009). Alzheimer's disease can be described as a chronic, neurological disorder causing a gradual loss of cognitive functions and eventually death. Impairments in occupational and social functioning are also related to this disease. According to Zec (1993) Alzheimer's disease is the most common form of dementia among older persons. Causes of the disease are unclear. Zec (1993) argues that other regions of the

brain, including the hippocampus and the amygdala, may be affected by the presence of senile plaques indicative of Alzheimer's disease. The deterioration of cognitive functions is diffuse and progressive with the onset of Alzheimer's disease. At the onset of the disease impairments are observed in declarative memory for new information. With the progression of the disease decline becomes more rapid. Alzheimer's has become a more prominent global health problem in recent years due to the increasing proportion of older people throughout the world.

1.2.7 The Seattle Longitudinal Study

However, this decline is not inevitable. Schaie (1984) demonstrated that some older adults do not show any decline until reaching eighty years of age. The intellectual capacities of the brain have been the subject of much examination from two major longitudinal studies spanning the last forty years. The Seattle Longitudinal Study and the Baltimore Longitudinal Study on Aging have tracked thousands of people in lifelong studies, recording the changes brought about by aging in the areas of physical, emotional and mental health.

Dr. K. Warner Schaie began the Seattle Longitudinal Study (SLS) in 1956. Since its establishment the SLS has been investigating participants at seven year intervals. At each interval, all persons who had previously participated in the study were asked again to participate. Additionally at each seven-year interval, a new group of people have been randomly selected and asked to participate. Approximately six thousand people have now participated at some time in this study. Of the original participants, 26 people remain who have now been in the study for 50 years.

Dr. Sherry L. Willis became principal co-investigator of the study in 1983. Schaie and Willis (1986) have demonstrated that Cognitive training techniques can reverse documented decline consistently over a 14-year period. Using a longitudinal design Schaie and Willis have investigated 229 older adults for over thirty years. Deterioration in two types of thinking was observed in approximately half of the participants studied. The types of thinking experiencing deficit included spatial orientation skills (the ability to piece together objects or road maps) and inductive reasoning power (problem solving). During the study participants received approximately five hours of mental training. This training consisted of exercises in learning spatial relationships, problem solving and increasing verbal and memory skills. After training the group was retested. Marked improvements were observed by about half the group

whose thinking had not declined. The most pronounced improvements were noticed in participants whose abilities had weakened. Forty percent of these participants regained what had been lost in the 14 years and after a 7 year follow up test the participants regained what had been learned.

As a result Schaie put forward some common elements among elderly who are most mentally fit including:

- Regularly doing a variety of activities including reading, travelling, attending cultural events, pursuing further education and joining professional organisations and clubs.
- Open to and quickly able to grasp new ideas
- Flexible and willing to change
- Married to a bright spouse
- Above-average education and income
- Free of chronic diseases
- Satisfied with personal or professional accomplishments

Alternatively Schaie also observed common attitudes and activities found in elderly that experience mental deterioration including adhering strictly to a routine and dissatisfaction with life (Goldman, Klatz & Berger, 1999).

1.2.8 The Baltimore Longitudinal Study of Aging (BLSA)

Similar to the Seattle study, the Baltimore Longitudinal Study of Aging (BLSA) has monitored a large group of people since 1957 (National Institute on Aging, 2008). This multidisciplinary observational study has investigated the physiological and psychological aspects of human aging, diseases and conditions that increase with age. Information from the BLSA may help to define strategies to improve quality of life in old age and prevent and delay loss of independence. Participants in this study have numbered in the thousands and have aged between twenty years and ninety years old. Participants have travelled to Baltimore at intervals of approximately two years for physical, psychological and mental function tests. A wealth of data has been amassed regarding the way in which people age physically, emotionally and cognitively. Some findings from the BLSA include:

- Top mental performance scores were achieved by people in every age group.
- Some people with high scores exhibited no mental decline at any age.
- There was no connection between intellectual performance and high blood pressure.
- Vocabulary scores did not change with age.
- Short-term memory declines with age.
- The ability to learn oral material begins to decline in people over age seventy.
- People aged over sixty make more mistakes in verbal learning than younger adults.

The Seattle and Baltimore studies have differed slightly with regard to participants and research methods. For example, the Baltimore Study began in the 1957 but did not include women until 1978. The Seattle study has worked with subgroups of volunteers to train people in order to attempt to change mental aging patterns. However similar conclusions have been reached about how the brain and mind ages and what can be done to offset the ageing process. When participants from both studies endeavoured to increase brain power, results indicate that they can remember more, can think more quickly and efficiently, and develop a better grasp of elusive concepts. These studies have found that deliberate, methodical mental training or exercises can make a demonstrable difference in people's lives (Goldman, Klatz & Berger, 1999).

Thompson and Foth (2005) also agree that cognitive decline is not universal or pervasive, and argue that older adults can benefit from cognitive training. Kramer and Willis (2002) surmise that both longitudinal and cross-sectional training research support the position that even individuals of advanced age have considerable plasticity in their cognitive functioning (meaning that they can benefit from training in specific cognitive skills).

1.2.9 Intelligence

Cognition can be described as the mental processes and activities used during the acts of perceiving, remembering and thinking. Cognition can also be described as the act of using those processes (Lemme, 1995). Traditionally aging has been viewed in psychology as defined by an automatic decline in cognitive and physical functions. This perspective of aging is known as the decrementalist view. Due to the prevalence of the decrementalist view the bulk of evidence yielded by research during most of the last century focused on cognitive decline. The decrementalist view was supported by evidence from early cross-sectional

studies of psychometric intelligence in adulthood. Studies of this era held to the view that most abilities peak at midlife, plateau throughout the late fifties followed by accelerated decline with age (Lemme, 1995). However this view of aging does not account for the immense variation among individuals regarding age related cognitive decline. Large individual differences exist in the degree, rate and pattern of cognitive change or decline. Large group data cannot account for these changes.

Different aspects of cognition follow different patterns of change over time, some being better preserved than others. The patterns of change differ regarding the different facets of cognitive functioning. Baltes (1987) argues that intelligence consists of two facets: fluid and crystallized intelligence. Fluid intelligence can be likened to the mechanics of cognition encompassing the inherited ability to think and reason. It is considered to reflect the underlying information processing and problem solving capabilities. Fluid intelligence while influenced by experience is thought to be more heavily dependent on the state of the brain. An example of fluid intelligence is the speed with which one can analyze information. Other examples include attention, memory capacity, reasoning ability, spatial orientation, abstract reasoning, word fluency and inductive reasoning.

Crystallized intelligence, however, refers to the accumulation of knowledge brought about and stockpiled over a lifetime of experience. Crystallized intelligence is thought to stem from education and lifelong experiences. This type of intelligence is reflected in tests of knowledge, general information, verbal meaning, word association, social judgment, number skills and a wide variety of acquired skills (Hooyman & Kiyak, 2010). Personality factors, motivation, educational, cultural opportunity are central to the development of crystallized intelligence. Crystallized intelligence is only indirectly dependent on the physiological influences that mainly affect fluid abilities. Research conducted on patterns of age related change have found distinct differences between the two components of intelligence. Continuous decline of fluid intelligence has been reported as early in life as the late twenties. Whereas measures of crystallized intelligence are evidenced by growth with age and begin to decline only in very old age (Baltes, 1987).

1.2.10 The Cognitive Reserve

The theory of the cognitive reserve has interesting implications in the area of cognitive skills training with older adults. The cognitive reserve refers to the ability of those

with high intelligence and high education to show less impairment than those with poor education and low intelligence. This has been evidenced by research on the differing levels of cognitive functioning among Alzheimer's patients. In the case of Alzheimer's those with such cognitive reserve have less of a negative impact on tasks when compared to other individuals with Alzheimer's disease. It has been suggested that individuals with high levels of cognitive reserve can cope for longer with the disease before it manifests itself (Halligan, Kischka & Marshall, 2003). The impact of late life cognitive skills training on the cognitive reserve is unclear.

1.2.11 Cognitive and Neural Plasticity

Hooyman and Kiyak (2010) describe cognitive plasticity as the capacity to accomplish the three mechanisms of Selection, Optimization and Compensation (SOC). An individual may reduce age related decline in cognitive abilities by selection of specific cognitive domains in which to adapt. Optimization can then occur whereby one maximizes ones abilities in the selected areas. Compensation occurs finally when degradation in some areas requires the enhancement of skills in other areas or the acquiring of new behaviours or knowledge to make up for lost abilities. Cognitive plasticity refers to the abilities to accomplish SOC and to recognize where one must compensate for these abilities. Older adults who cope best with old age appear to have the most cognitive plasticity indicative of an ability to read one's environment and adapt to change. Prior learning experiences, stimulating environments and activities have been found to improve plasticity.

Cognitive plasticity is underpinned by the processes of neural plasticity. Neural plasticity can be described as the changes that occur in brain structure and function as a result of the addition of the neurons and synaptic connections between neurons, activating specific areas of the brain. This has been exemplified in cases of professional musicians having more gray matter in areas of the brain associated with finger movements. Hooyman and Kiyak (2010) suggest that computer and internet use activates more areas of the brain especially where decision making and complex reasoning occur. They also suggest that use of computers and the internet can improve older people's cognitive functioning and ability to maintain active aging. The type of cognitive and demographic variables that appear to affect older adults performance on computer related tasks include crystallized intelligence, visual memory, perceptual speed, age and education. The Brain Fitness movement has used this

evidence to create a variety of electronic brain games aimed at the middle-aged and older adults for use on platforms such as the Nintendo DS, Nintendo Wii, Apple iPhone and on the internet.

1.2.12 Assistive Technology Systems

Assistive technologies as investigated by Pollack (2005) can be described as technologies that help supplement human care giving and have the potential to improve quality of life for older individuals. Assistive technologies can also help older people live in home for longer periods of time. According to Pollack (2005) there are three different types of assistive technology systems: assurance systems, compensation systems and assessment systems. Assurance systems operate by providing assurance that the older adult is safe and is performing necessary daily activities, and if not, alerting a caregiver, by helping the elder compensate for her impairment, assisting in the performance of daily activities and by assessing the older people's cognitive status. Assistive technologies include property exit sensors to alert care givers that a resident has left the home and bed occupancy sensors to alert a care giver that a resident has left the bed. Other types of in home technology include flood detectors, temperature extreme sensors, carbon dioxide detectors, natural gas detectors and smoke detectors. These technologies exist to warn an older person of an imminent problem such as allowing a sink to overflow. Assistive technologies can serve a dual purpose: helping older adults to live at home for longer periods, improving quality of life and potentially saving enormous amounts of money. These technologies have established histories backed by considerable research. Cognitive training programs or games are a considerably more recent field with less history and research.

1.2.13 Cognitive Skills Training

Bell et al (2002) found that when older adults aged 65-94 years were provided with cognitive skills training (memory, reasoning, and speed of processing) the effects could be seen even at a two-year follow up. Bell et al also suggest that these improvements may reduce the eventual decline of cognitively demanding everyday functioning across these groups. A further five-year follow up of the Bell et al (2002) study by Willis et al (2006) found that specifically, those who had been provided with the cognitive reasoning training

reported significantly less difficulty in the instrumental activities of daily living, but that each of the interventions maintained effects on its specific targeted cognitive ability through the five years.

1.2.14 The ACTIVE Trial

The Advanced Cognitive Training for Independent and Vital Elderly Trial (ACTIVE) is a large randomized single blind trial with a representative sample of older adults. The ACTIVE Trial was set up to examine the effectiveness of three cognitive training interventions memory, inductive reasoning and speed of processing on improving mental abilities and daily functioning in independently living older adults over 65 years. Results were compared to a no contact control group. Results were gathered form a sample size of 619 individuals. Memory training focused on verbal episodic memory, which deals with consciously recalling specific events or episodes (Hooyman & Kiyak, 2010). Participants were thought mnemonic strategies for remembering lists and sequences of items, text, and main ideas and details of stories and other text-based information. Training exercises involved recalling laboratory-like episodic memory tasks as well as tasks related to everyday activities such as recalling a shopping list (National Institute on Aging, 2006). Langbaum, Rebok, Bandeen-Roche and Carlson (2009) investigated memory training among older adults. Latent class analysis was used to investigate data from the ACTIVE trial in order to examine results from participants receiving memory training to determine if there was a distinct pattern of responsiveness to memory training.

Findings from ACTIVE reported that on a memory composite score immediately following training, 26% of the memory trained participants demonstrated reliable improvements. Results indicate that participants gravitate to specific mnemonic techniques following memory training. Furthermore baseline memory and speed of processing abilities, age and education were found to be predictive of specific response patterns. Findings suggest that older adults' responses to memory training can be characterized and predicted. Over 90% of ACTIVE participants reaching completion of the memory training improved on at least one memory measure. This finding lends support for the idea of plasticity in cognitive functioning in older adults. The general trend of cognitive decline with aging has been explored above, however with memory training; the ACTIVE trial indicates that older adults can improve their performance on many tests. This study presented a variety of improvement

patterns and suggests that the amount and degree of plasticity varies from person to person supporting the theory of the cognitive reserve. Results can be questioned as participants with higher levels education have more knowledge and experience using mnemonic strategies. However given the high percentage of training benefits exhibited by participants and the variety of educational attainment among participants, this explanation is unlikely (Langbaum, 2009).

Rapp, Brenes and Marsh (2002) carried out a multi-faceted intervention that included education about memory loss, relaxation training, memory skills training, and cognitive restructuring in older adults. They found that these interventions led to significantly better memory appraisals than controls at the end of treatment and at a six-month follow-up.

The benefits of cognitive skills training are not restricted to healthy older adults. There have been a number of studies recently which outline the link between intellectual activity and Alzheimer's disease. Scarmeas and Stern (2004) provide a summary of many of these studies, indicating that the evidence demonstrates increased participation in intellectual aspects of life, in conjunction with social and physical aspects, may result in functionally more efficient cognitive networks and therefore provide a cognitive reserve that delays the onset of clinical manifestations of dementia. Even more recently, Wilson, Scherr, Schneider, Tang and Bennett (2007) carried out annual clinical evaluations on more than 700 elderly people for up to five years. They found that more frequent participation in cognitive activity was associated with reduced incidence of Alzheimer's disease, with a cognitively inactive person being 2.6 times more likely to develop Alzheimer's disease than a cognitively active person. This association remained after controlling for past cognitive activity, lifespan socioeconomic status, and current social and physical activity. Frequent cognitive activity was also associated with reduced incidence of mild cognitive impairment and less rapid decline in cognitive function.

However Hofmann, Hock, Kühler and Müller-Spahn (1996) found that an interactive computer-based cognitive training intervention led to no general cognitive improvement in patients suffering from mild to moderate Alzheimer's disease, despite being well received and improvement being shown on patients' performance on the programme itself. Hofmann et al (1996) hence questioned whether the results achieved with computer based training can be transferred to real life situations. However, this study focused only on Alzheimer's disease treatment, not prevention, and it is possible that completing the tasks earlier in the lifespan may have prevented the disease and its associated difficulties from developing in the first place.

1.2.15 Scientific Basis for *Brain Training*

As was previously stated Kawashima's *Brain Training* endeavours to increase the delivery of oxygen, blood and amino acids to the prefrontal cortex resulting in a more healthy brain. Kawashima used brain imaging studies to investigate the effects of *Brain Training* on the brain. Kawashima initially studied *Brain Training* with primary school pupils in word memorization tasks. Results from this study indicated a 20% to 30% improvement in word memorization following a two minute calculation exercise. Furthermore Kawashima et al (2005) studied 16 dementia Alzheimer type patients. Participants were asked to perform a training program using learning tasks in reading and arithmetic twenty minutes a day, two to six days a week for a period of six months. The function of the frontal cortex of the participants was assessed by Frontal Assessment Battery at bedside (FAB). The FAB was devised as a short bedside cognitive and behavioural battery to measure frontal lobe functions (Dubois et al., 2000). The FAB consists of six subsets exploring different functions related to the frontal lobes, designed originally for validating frontal lobe function in neurodegenerative diseases. When compared to a control group given no training, the FAB score results from the experimental group exhibited a statistically significant improvement. Over the 6-month period the FAB score of the control group showed a slight decrease, the difference between the scores of the experimental and control groups was statistically significant. Kawashima (2007) then used an optical topography system to verify how the prefrontal cortex was stimulated while using the *Brain Training* software. Exercises producing the largest increase in brain activity were selected for use in the software (Kawashima, 2007). Kawashima's research indicated that cognitive training can activate the prefrontal cortex further research investigated how these benefits might transfer to cognitive functions.

1.2.16 Transfer of Cognitive Training Benefits to other Cognitive Functions

Uchida and Kawashima (2008) conducted a single blind randomized controlled study with convincing evidence that cognitive training provides beneficial transfer to other cognitive functions. This study investigated whether cognitive training can have a positive

transfer effect on other cognitive functions necessary for improving, performance in real life tasks and independent living with older adults.

Uchida and Kawashima (2008) investigated 98 community-dwelling adults aged over 70 years. The experimental group consisted of 51 participants and the control group consisted of 47 participants. A similar intervention to that used with senile dementia patients in the Kawashima et al (2005) study was given to the older adults. The experimental intervention formulated consisted of asking first to fourth grade Japanese elementary students to solve arithmetic problems and language problems. The arithmetic problems ranged from single digit addition to three-digit division. Those of the language problems consisted of reading and comprehending Japanese Haiku and stories. Participants were asked to go to classes once a week and were given 15 minutes to solve the problems presented on five work sheets for each task.

The intervention was measured using the Frontal Assessment Battery at bedside (FAB) (Dubois et al., 2000) and the digit symbol substitution test (DST) of the WAIS-R (Wechsler, 1981). The DST of the WAIS-R is a sensitive subtest for screening general brain dysfunction. Pre-testing was conducted two weeks prior to the start of the intervention. The intervention was administered in a local community centre. Post-testing took place a week after the end of the intervention. Participants continued the cognitive intervention between five and seven days per week for six months. Significant improvements were found in terms FAB and DST scores. Significant increases were observed in lexical fluency and sensitivity to interference sub scores of the FAB on the experimental group. The lexical fluency task increase involves a self organized retrieval from semantic memory. Improvement in lexical fluency could be due to the intervention category as continuous training by reading problems increases semantic knowledge. Two areas that the intervention did not train were perceptual speed and working memory. Improvements were indicated in these areas as tested by the DST. This finding supports evidence of improvement in non-targeted functions. Kawashima suggested that further estimation of the longevity of the intervention-induced improvement is necessary to investigate the long term benefits of *Brain Training*.

1.2.17 Computerized Cognitive Training

One of the most recent publicised studies on *Brain Training* was conducted in Britain by Owen et al (2010) with a total of 11,430 participants. This online study investigated the

effects of the transfer of cognitive training benefits to other untrained tasks. Viewers of a popular BBC science programme logged into a website to receive cognitive training online several times per week on cognitive tasks designed to improve reasoning, planning, visuospatial skills and attention. Benchmarking testing was conducted to give a baseline on tests of reasoning, verbal short term memory, spatial working memory and paired associates learning. Participants were assigned to either two experimental groups or a control group. Group one training consisted of reasoning, planning and problem solving abilities. Group two training consisted of a broader range of cognitive functioning including tests of short term memory, attention, visuospatial processing and mathematics. Group two training was compared to that of commonly available *Brain Training* devices. The control group did not receive training but were asked to answer a number of obscure questions using any available online resource. Participants were post-tested after 6 weeks. On average participants completed training every two days and were aged between 18 and 60. Mean ages for the three groups fell between 39.14 and 40.51 years of age. Comparisons across all groups indicated that effect size on all the benchmarking tests were very small. However improvements on tests that were actually trained was convincing as all groups improved on their specific training tasks but there was no improvement on the benchmarking tests measuring generalized improvements in cognitive functioning. Benchmarking tests were chosen for their known sensitivity to small changes in cognitive functioning in disease. This study did not support the use of a computerized *Brain Training* device in order to improve cognitive functioning in healthy participants. Owen et al (2010) suggest that face to face cognitive training could yield more benefits. It should be noted that the Owen et al (2010) study was not peer reviewed and therefore has less scientific merit.

Contrastingly Smith et al (2009) found improvements on generalized measures of memory and attention when compared to an active control group. Smith et al. studied 487 healthy adults aged 65 years and over. Participants took part in training lasting one hour per day, five days a week for eight weeks. Participants were randomized to receive a broadly available brain plasticity computerized cognitive training program "Brain Fitness" or an alternative novelty and intensity-matched general cognitive stimulation program. The cognitive training program involved exercises designed to improve the speed and accuracy of auditory information processing. Active control group training consisted of answering quiz questions on history, art and literature incorporating mental stimulation and offered the possibility of performance improvements. The primary memory test used was the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998)

utilizing list learning, story memory, digit span forward, delayed free recall, delayed list recall and delayed free story recall. In addition to the RBANS a number of other memory assessments of auditory memory and attention were used to provide further robustness of generalization to the testing measures.

Results indicated that auditory memory and attention improvement was significantly greater in the experimental group than in the control group. Multiple secondary measures of memory and attention showed significantly greater improvements in the experimental group. This study found performance improvements generalized to untrained standardized measures of memory and attention, implying that robust gains occurred across auditory-based cognition.

The ACTIVE study included speed of processing training exercises that share certain design principles with the experimental condition training employed by Owen et al (2010) such as intensive practise, focus on perceptual speed and accuracy, use of adaptive algorithms and emphasis on attention and reward (Jobe et al, 2001). Smith et al (2009) suggests that cognitive training programs utilizing intensive practise, focus on perceptual speed and accuracy, use of adaptive algorithms and emphasis on attention and reward in order to exhibit generalization. Furthermore this may be effective at countering age-related cognitive decline. Kawashima's *Brain Training* incorporates many of these design principles and endeavours to slow the onset of age related cognitive decline.

1.2.18 Adherence to Cognitive Training

Adherence to cognitive training regimes or the extent to which the participant uses the training tool can influence greatly the benefits derived. Jaeggi, Buschkuehl, Jonides and Perrig (2008) investigated the effects of cognitive training on working memory. Findings provided evidence for the transfer from a demanding working memory task to measures of fluid intelligence. Results indicated that the extent of gain in intelligence is critically dependant on the amount of training. That is the more training a participant receives the more improvement in fluid intelligence. However controlling the extent to which a participant uses a self administered training tool as prescribed by the researcher or tool itself is a factor that is difficult to control. As with patients taking medication it is clear that the full benefit of many interventions can only be achieved if the user follows the treatment regime reasonably closely. Osterberg and Blaschke (2005) reported adherence rates among patients suffering

from a chronic condition at 43-78 %. Typical barriers to adherence include forgetfulness, other priorities, decision to omit, lack of information and emotional factors. Shatil, Metzer, Horvitz and Miller (2010) investigated unprompted adherence to a cognitive training program in patients with multiple sclerosis. With regard to promoting adherence Horvitz and Miller (2010) emphasized the importance of personalized adaptive feedback. Features of the training program used to achieve adaptive feedback in the study included using a baseline cognitive evaluation to individualize the training regime. Secondly continually adapting difficulty level to the participant, using an interactive adaptive system and lastly, providing graphic and verbal feedback after each training task. This study found that partial or total lack of adherence can be due to fatigue, other health related limitations, lack of motivation, or to lack of interest in the cognitive training program.

1.3 Research Questions and Hypotheses

Despite the research to date in this area, there are a number of flaws and omissions in the scientific body of knowledge. Firstly, Butcher (2008) indicates that while a number of cognitive training technologies exist, they have, in the main, been evaluated by their own developers. Butcher emphasizes that it is essential that independent tests be completed on these products in order to determine their efficiency. The current study aims to address this issue by independently evaluating the *Brain Training* software.

Secondly, Thompson and Foth (2005) acknowledge that the cognitive skills training has to be presented in ways that are acceptable to older adults, and that the methods used need to be readily accessible, affordable and enjoyable. Hence it is essential that testing is completed to ensure that the new methods being employed are actually desirable to older adults. Again, the current study aims to determine if the commercially available software meets this requirement.

Finally, the relative benefits of technological vs. text-based cognitive skills training tools have not yet been addressed. The current study aims to identify which of the two methods results in the greatest benefit for older adults over a two month period. These factors have led to the research questions.

Research Question 1: Does using a cognitive skills training tool have a significant effect on numerical ability, memory, and intelligence?

Research Question 2: What is the difference between using text-based and technology based cognitive skills training tools?

Research Question 3: What attitudes do participants have concerning *Brain Training*?

Research in the area of cognitive skills training has found contrasting findings relating to the benefit of cognitive training. Studies have indicated improvements on numerical ability, memory and intelligence. In the growing field of *Brain Training* many tools are designed to be used on technological systems. However the Survey of Older People and ICTs in Ireland 2008 indicates that the majority of older people do not use ICTs (Work Research Centre & Age Action Ireland, 2009). These factors have led to the following hypotheses, which will be dealt with in Chapter Two.

1.3.1 Older Adult Hypotheses

Numerical ability is a specifically targeted cognitive ability that *Brain Training* endeavours to train. Solving arithmetic problems engages a number of cognitive functions such as recognition of visually presented numbers, arithmetic operations and control of hand movements (Wingfield & Grossman, 2006). Uchida and Kawashima (2008) administered a cognitive training intervention consisting in part of solving arithmetic problems resulting in improvements in cognitive function. In order to investigate the effectiveness of *Brain Training* on numerical ability the following hypothesis was formed:

H1 The use of cognitive skills training tools will result in a significant improvement in a numerical ability as measured by a numerical ability test (NAT).

Memory is another aspect of cognition that *Brain Training* endeavours to train. Improvements in memory have been found following cognitive training in a number of studies such as Schaie and Willis (1986) and Bell et al (2002). Declines in memory associated with old age are well documented. *Brain Training* is primarily concerned with activating the prefrontal region of the brain involved in memory processes. In order to investigate the effectiveness of *Brain Training* on memory the following hypothesis was formed:

H2 The use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S).

Kawashima states that exercises used in *Brain Training* can increase the delivery of oxygen, blood and amino acids to the prefrontal cortex resulting in more neurons and neural

connections, characteristic of a healthy brain (Kawashima, 2007). Many *Brain Training* tasks endeavour to improve fluid intelligence. Jaeggi, Buschkuehl, Jonides and Perrig (2008) investigated cognitive training using a working memory task. Results indicated that there was a transfer from a demanding working memory task to fluid intelligence. In order to investigate the effectiveness of *Brain Training* on intelligence the following hypothesis was formed:

H3 The use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Wechsler Abbreviated Scale of Intelligence (WASI).

A number of studies have recently investigated computerized *Brain Training* tools. Owen et al (2010) did not support the use of computerized cognitive training to enhance cognitive functioning whereas Smith (2009) provided support for the use of computerized brain plasticity training to improve auditory memory and attention in older adults. Much research has been conducted on cognitive training programs presented in text-based platforms such as Uchida and Kawashima (2008). However there is a considerable lack of research comparing text-based and technological based cognitive training tools. The literature indicates that in Ireland people aged over 65 years are the least likely to use computers and the internet (CSO, 2009). In order to investigate the preference of older adults for the type of *Brain Training* platform the following hypothesis was formed:

H4 Participants will exhibit a preference towards either the technology or text based cognitive skills tool.

Research indicates that *Brain Training* can improve numerical ability. However little research exists directly comparing the effects of *Brain Training* presented through different platforms on numerical ability in older adults. In order to investigate the effects of different types of *Brain Training* platforms on numerical ability in older adults the following hypothesis was formed:

H5 The use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools.

A number of studies such as Schaie and Willis (1986) and Bell et al (2002) indicate that *Brain Training* can improve memory. Yet there is little research investigating the effects of *Brain Training* on memory in older adults presented through different platforms. In order to investigate the effects of different types of *Brain Training* platforms on memory in older adults, the following hypothesis was formed:

H6 The use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools.

Jaeggi, Buschkuehl, Jonides and Perrig (2008) indicated that intelligence can be improved through training on a demanding working memory task. *Brain Training* tasks demand working memory. Yet little research exists investigating the effects of *Brain Training* on intelligence in older adults presented through different platforms. In order to investigate the effects of different types of *Brain Training* platforms on intelligence in older adults the following hypothesis was formed:

H7 The use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by the WASI compared with the technological based cognitive skills training tools.

1.3.2 Third Level Student Hypotheses

In contrast to the large amount of research on cognitive skills training with older adults relatively little research has been conducted with third level students using *Brain Training* tools. An investigation of cognitive skills training with third level students provides an opportunity to find interesting comparisons and contrasting findings between students and participants of older age. The same rationales outlined in section 1.3.1 apply to the development of the student hypotheses, which will be dealt with in Chapter Three.

In order to investigate the effects of *Brain Training* on numerical ability in third level students the following hypothesis was formed:

H8 The use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test (NAT).

In order to investigate the effects of *Brain Training* on memory in third level students the following hypothesis was formed:

H9 The use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S).

In order to investigate the effects of *Brain Training* on intelligence in third level students the following hypothesis was formed:

H10 The use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Raven's Standard Progressive Matrices (SPM).

In order to investigate the preference of third level students for the type of *Brain Training* platform the following hypothesis was formed:

H11 Participants will exhibit a preference towards either the technology or text based cognitive skills tool.

In order to investigate the effects of different types of *Brain Training* platforms on numerical ability in third level students the following hypothesis was formed:

H12 The use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools.

In order to investigate the effects of different types of *Brain Training* platforms on memory in third level students the following hypothesis was formed:

H13 The use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools.

In order to investigate the effects of different types of *Brain Training* platforms on intelligence in third level students the following hypothesis was formed:

H14 The use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by Raven's SPM compared with the technological based cognitive skills training tools.

1.4 Conclusion

Few studies exist in the area of cognitive training investigating both older adults and student age participants. There are also few studies investigating the effectiveness of the *Brain Training* tools. Given the prevalence of *Brain Training* tools a critical evaluation is needed by an independent researcher. The area of cognitive skills training could increase given the current population trends. For this reason it is important to assess the efficacy of tools that endeavour to offset problems associated with age related cognitive decline such as dementia and Alzheimer's. This dissertation attempts to investigate improvements on measures of numerical ability, memory and intelligence. Furthermore the dissertation will investigate the difference between text-based and technological skills training tools. Lastly the dissertation will investigate the attitudes of both older adult and participants of third level student age.

Chapter Two

A Study of Older Adults using Text-Based and Technology Based Skills Training Tools

2.1 Introduction

This chapter describes the methodology, results and discussion of the quantitative research relating to older adults. The aim of this section of the research was firstly to investigate the effect of cognitive skills training tools on intelligence, memory and numerical ability in older adults. Secondly the aim of the research was to investigate the difference between using a text-based cognitive skills training tool and a technologically based cognitive skills training tool. Thirdly the aim was to investigate the attitudes of older adults concerning cognitive skills training tools. The following hypotheses were investigated:

H1 The use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test.

H2 The use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S).

H3 The use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Wechsler Abbreviated Scale of Intelligence (WASI).

H4 Participants will exhibit a preference towards either the technology or text based cognitive skills tool.

H5 The use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools.

H6 The use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools.

H7 The use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by the WASI compared with the technological based cognitive skills training tools.

2.2 Methodology of the Research

2.2.1 Design

In order to choose an appropriate experimental design method to investigate this topic a number of different designs were considered. A qualitative design such as an interview or case study can provide rich data on one or more participants using either the text based or technological cognitive skills training tool (Robson, 2002). In order to investigate hypotheses 1, 2, 3, 5, 6 & 7 studying quantifiable improvements in cognition a quantitative method was deemed more appropriate. In order to investigate hypothesis four both quantitative and qualitative designs were used. In this way both quantitative and qualitative designs were used in a complimentary fashion.

The design chosen was a Solomon four-group experimental design in order to determine which intervention demonstrated the greatest improvement in older adults' cognitive abilities. In this experimental design, two groups form a technological intervention and text-based intervention group pair without pre-tests, and two other groups include the pre-tests (Robson, 1993, pp. 89-90). This eliminates interference from pre-testing effects in the third and fourth groups, and the possibility of achieving greater precision by measuring the treatment effect on a within-subject basis in the first two groups. Table 2.1 illustrates how the Solomon four-group experimental design utilizes four different comparison groups.

Table 2.1: Solomon Four Group Experimental Design

	Intervention Used	Pre-Test Included
Group 1	Technological	No
Group 2	Text-based	No
Group 3	Technological	Yes
Group 4	Text-based	Yes

2.2.2 Participants

Participants were recruited using purposive sampling. Robson (2002) describes purposive sampling as that which allows a researcher to judge whether a particular population

are of interest and allows the researcher to satisfy the specific needs of a project. The population studied were older adults over the age of 65. A number of elderly groups and clubs including Active Retirement Ireland, Exercise for the Elderly and The University of Third Age (U3A) were contacted and advertisements were placed in library notice boards in order to recruit.

Table 2.2: Age and Number of Participants per Group

Condition	n	Minimum - Maximum	Range	Mean Age	Std. Deviation
1 Ds	4	70 - 71	1	70.75	.50000
2 Book	7	65 - 76	11	72.00	3.82971
3 Pre tested DS	14	65 - 81	16	73.71	5.32669
4 Pre tested Book	15	65 - 87	22	74.26	6.55163

In some instances participants were recruited that were known to the researcher or supervisor. Participants were not asked explicitly about any health or mental health diagnosis. Screening questionnaires (see Appendix A) were given to participants in order to assess the level of technology use and to assess whether participants had used either the technological or the text-based intervention prior to testing. In an instance where a participant indicated full competence in using either intervention the participant was thanked and asked not to take part in the study. Table 2.2 describes the number of participants tested in each condition, minimum and maximum ages, the range, mean age and standard deviation. Participants were recruited into one of four conditions; condition 1 (technological aid with no pretest) condition 2 (text aid with no pretest) condition 3 (technological aid with pretest) condition 4 (text aid with pretest). Figure 2.1 illustrates the age range of each condition: condition 1(range= 1 year), condition 2 (range = 11 years), condition 3 (range =16 years) and condition 4 (range = 22 years). The total mean age of participants was 73.32 (sd = 5.34).

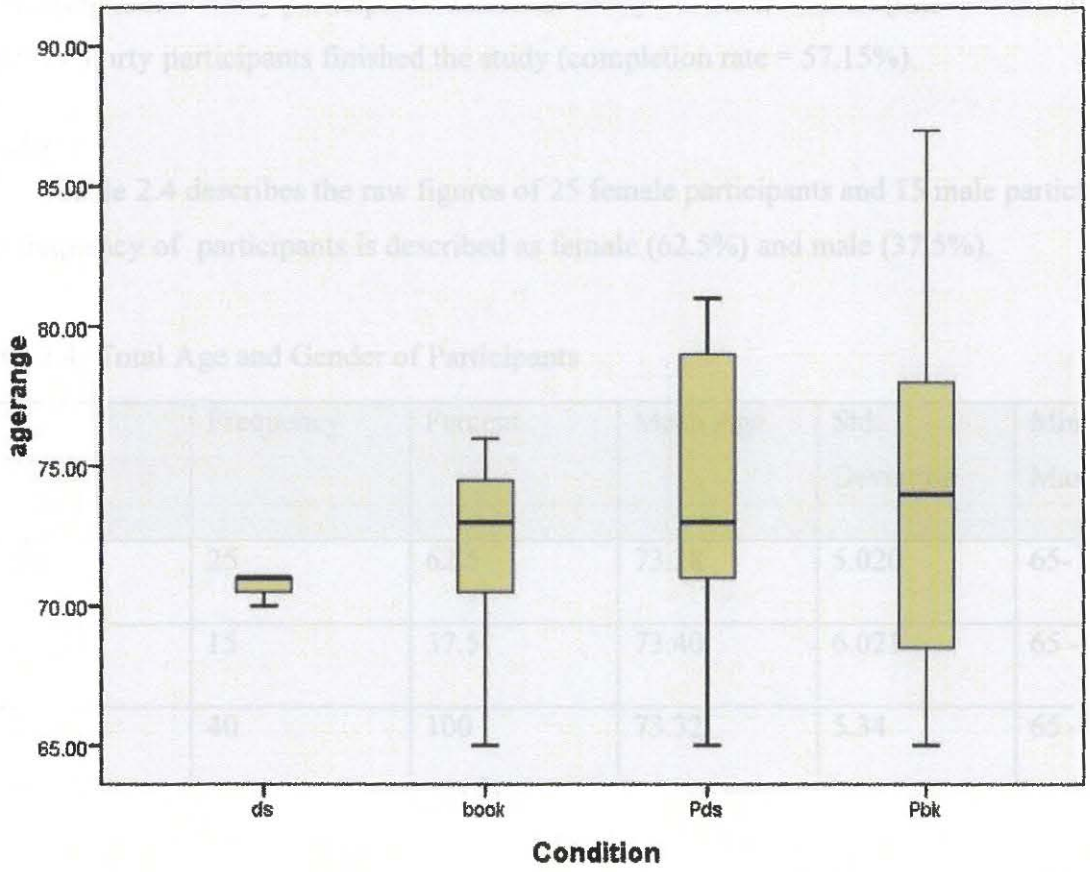


Figure 2.1: Age Range and Condition

Table 2.3 describes the overall participant statistics. The table indicates the number of participants; contacted to take part in the study, started using an intervention, that dropped out and the number that finished the study.

Table 2.3: Overall Participant Statistics

	Adults Contacted	Overall Started	Drop Out	Finished
	545	70	30	40
Total %		100	42.85	57.15

Five hundred and four older adults were approached regarding participation in the study. Seventy older adults agreed take part in the study (response rate = 12.84%). No older adults were deemed ineligible to participate in the study due to past experience using one of

the training tools. Thirty participants started the study but did not finish (rate of attrition = 42.85%). Forty participants finished the study (completion rate = 57.15%).

Gender

Table 2.4 describes the raw figures of 25 female participants and 15 male participants. The frequency of participants is described as female (62.5%) and male (37.5%).

Table 2.4: Total Age and Gender of Participants

	Frequency	Percent	Mean Age	Std. Deviation	Min – Max
Female	25	62.5	73.28	5.020	65- 83
Male	15	37.5	73.40	6.021	65 - 87
Total	40	100	73.32	5.34	65 – 87

Figure 2.2 describes the age range of female participants (65 to 83 years) and the age range of male particpants (65 – 87 years).

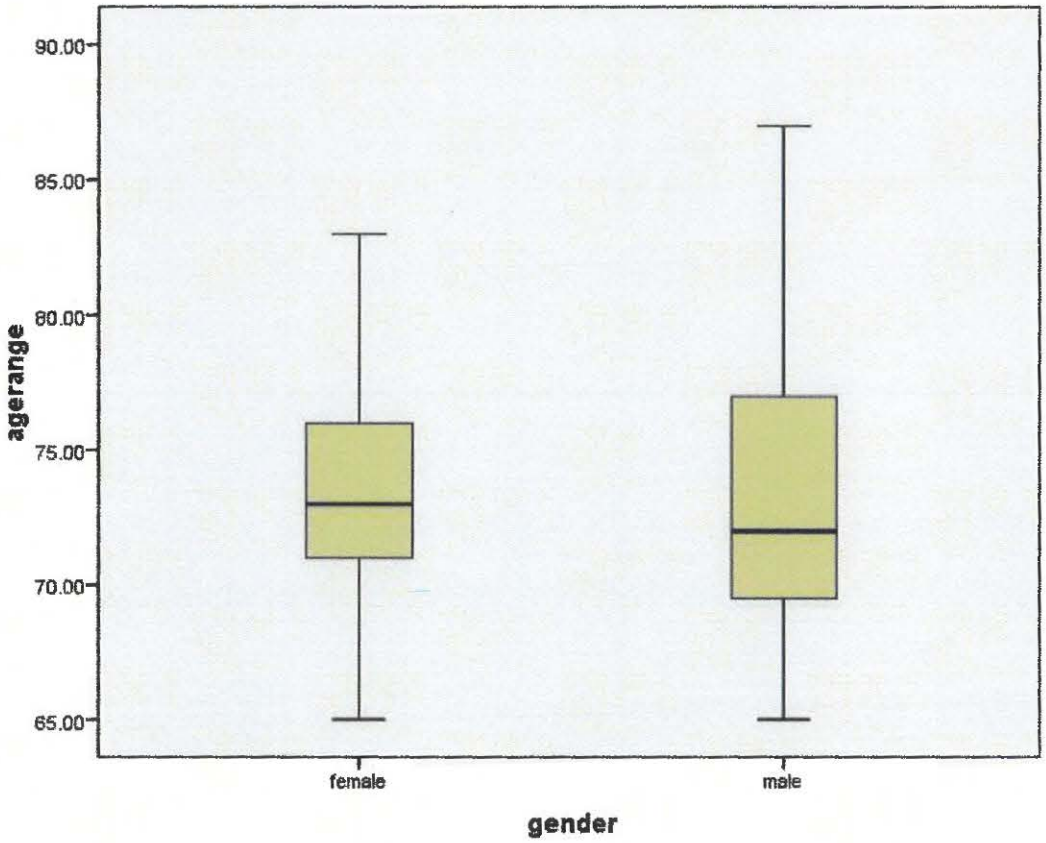


Figure 2.2: Gender and Age Range

Table 2.5 presents a breakdown of the conditions by gender. There was unequal gender distribution among the groups.

Table 2.5: Gender by Group

	DS	Book	Pre-test DS	Pre-test Book
Female	1	5	10	9
Male	3	2	4	6

2.2.3 Materials

A technological and text based intervention, screening questionnaires, consent and debrief forms and a number of pre and post tests were sourced and created. The technological intervention consisted of the temporary provision of a Nintendo DS Lite Games Console and a copy of the game *Dr. Kawashima's Brain Training: How Old is Your Brain?* The text-based intervention consisted of a similar alternative developed by the same neuroscientist - Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*".

Screening questionnaires (see Appendix A) and consent forms (see Appendix B) were created by the researcher. For more information on the development of the screening questionnaires please refer to screening questionnaire section below. Pre-tests and post-tests consisted of a short test of numerical problem-solving abilities (Appendix C), Wechsler Abbreviated Scale of Intelligence (WASI) and The Memory Assessment Clinics Self-Rating Scale (MAC-S) see Appendix D. Participants were then asked to complete a short post-test questionnaire (Appendices E & F) determining level of satisfaction with the intervention they received. Finally participant debriefs were administered to participants (Appendix G).

Nintendo DS Lite Games Console

The technological intervention consisted of the temporary provision of a Nintendo DS Lite Games Console. The Nintendo DS Lite is a dual screen handheld game console consisting of a display screen for explaining controls and exercises and a touch screen manipulated through the use of a stylus. Since the release of the Nintendo DS Lite there have been updated versions of the games console released. This study however is concerned with the original Nintendo Ds Lite.

Figure 2.3: Nintendo DS Lite Console

Dr. Kawashima's Brain Training: How Old is Your Brain?

Dr. Kawashima's Brain Training features activities designed to help stimulate the brain including solving simple mathematics problems, counting people going in and out of a house simultaneously, drawing pictures on the Nintendo DS touch screen, and reading passages of literature aloud. Participants use the daily training option in order to check their brain age and do everyday training. The user must first create a personal data file where daily testing results are stored. The user than takes a brain age check.

Brain Age Check

A brain age check exists in order to determine one's "brain age". Three tests must be completed in succession to receive a brain age. Tests used in the Brain age check include Calculations x20, Stroop test, Word Memorization, Speed Counting, Connect Maze and Number Cruncher (described in greater detail in Appendix H). When three tests have been completed the user is given a brain age which they try to reduce by using the daily training programs (see Appendix H).

Daily Training

In order to start daily training the participant must tap "Training" on the main menu. The user can then complete a number of training programs (see Appendix H). On completion of each training program progress is tracked on a graph. The user must complete one training

program per day in order to receive a stamp. When a new file is started only three programs are available. By receiving stamps the user can unlock more training programs. When the user has unlocked all the training programs there are a total of nine types of daily training to choose from. Types of training include Calculations x20, Calculations x100, Reading Aloud, Low to High, Syllable Count, Head Count, Triangle Math, Time Lapse and Voice Calculation. Between daily training and the brain age tests a total of 14 tasks are available for the user of the *Brain Training* game.

Kawashima's (2007) Train Your Brain: 60 Days to a Better Brain

The text-based intervention consisted of a book developed by the same neuroscientist - Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Activities included in the book consist of solving simple mathematics equations quickly five days a week, a counting test measuring the time required to count from 1 to 120, a word memorization test and a Stroop test are completed on a weekly basis. For a detailed account of the book see Appendix I.

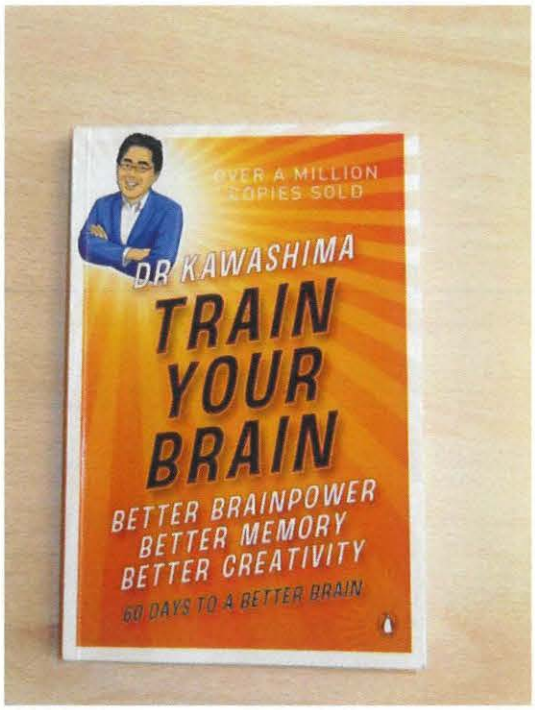


Figure 2.4: Kawashima's (2007) Train Your Brain: 60 Days To A Better Brain

Screening Questionnaires

Screening questionnaires (see Appendix A) were created by the researcher to establish both the participant technology usage and whether the participant had used either intervention

on a regular basis before the study. Survey questions were asked about; general activities, the Nintendo DS Lite console, use of Kawashima's (2007) *Train Your Brain: 60 Days to a Better Brain*; internet, e-mail, word processing and computer management. Participants were asked to rate the level of confidence in their ability to complete each task along a five point Likert scale for example: "Access an Internet site via its website address", "Do Crossword or Word Search", "Played Dr Kawashima's *Brain Training*". The screening questionnaire also provided some demographic information including; gender, age, level of education and prior employment.

Consent Form

A consent form was developed for use with participants (see Appendix B). Participants were informed of the aims of the study and what taking part would entail. All participants were informed that all data obtained would be treated with full anonymity and confidentiality and no individual participant would be identifiable if published. This statement also indicated to participants that they were free to decline to answer any question, withdraw from the study at any time, or refuse to take part from the beginning, without any negative consequences. Participants were given pseudonyms to ensure anonymity and any participant information could only be accessed via a password known only to the researcher. At the end of the document, there is a declaration and a check box. By ticking the box, the participant is agreeing that their voice may be recorded during testing; by signing the ethical statement the participant is giving informed consent to take part in the study.

Numerical Ability Test

In order to test numerical ability a numerical ability test was formulated by the researcher (see Appendix C). The numerical ability test was based on the calculations found in Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Fifty calculations were presented to participants consisting of multiplication, addition and subtraction. Participants were asked to complete the calculations as quickly as possible. The time taken to complete the calculations was converted into seconds and used as the raw score. Where a participant answered calculations incorrectly a five second penalty was added onto the overall score for each incorrect answer. An improvement in numerical ability is indicated when a participant receives a lower time taken to complete calculations than the previous time.

Wechsler Abbreviated Scale of Intelligence (WASI)

The Wechsler Abbreviated Scale of Intelligence (WASI) measures word knowledge, verbal concept formation, fund of knowledge, verbal reasoning, concept formation, visual information processing, abstract reasoning skills, the ability to analyze and synthesize abstract visual stimuli, nonverbal concept formation, visual perception and organization, simultaneous processing, visual-motor coordination, learning, and the ability to separate figure and ground in visual stimuli (Pearson, 2008). The WASI can be used to obtain a reliable brief measure of intelligence with individuals aged between 6 and 89 years. The norms for the WASI have been standardized with 2,245 cases. The WASI can be administered using the four (FSIQ-4) or two (FSIQ-2) subtest format. During testing the four subtests format was used. The four subtests include Vocabulary, Block Design, Similarities and Matrix Reasoning. An increase in mean score on the WASI indicates an improvement on memory.

The WASI Vocabulary subtest is a 42-item task. Items 1-4 of the Vocabulary subtest require the participant to name pictures, which are displayed one at a time. Items 5-42 are orally and visually presented words that the participant orally defines. An example of a question asked in the Vocabulary subtest of the WASI is "What is Lunch?" a correct answer would indicate that lunch is a meal eaten at the middle of the day between breakfast and dinner. This subtest is a measure of the individual's expressive vocabulary, verbal knowledge and fund of information. In addition, the vocabulary subtest provides a measure of crystallized intelligence and general intelligence while tapping other cognitive abilities, such as memory, learning ability, and concept and language development.

The Block Design subtest is comprised of a set of 13 printed two-dimensional geometric patterns the participant is asked to replicate within a specific time limit. The pattern is replicated using cubes that are red and white in colour. Block Design is a measure of abilities relating to spatial visualization, visual-motor coordination and abstract conceptualization. It is also a measure of perceptual organization and general intelligence.

The Similarities subtest contains four picture items and 22 verbal items. For each of Items 1-4, the participant is shown a picture of three common objects on the top row and four response options on the bottom row. The participant responds by pointing to the one response option that is similar to the three target objects. For each verbal item, a pair of words is presented orally, the participant is then asked to explain the similarity between the common objects or concepts that the two words represent. This subtest is a measure of verbal concept formation, abstract verbal reasoning ability and general intellectual ability.

The Matrix Reasoning subtest comprises a series of 35 incomplete gridded patterns that the participant completes by pointing to or stating the number of correct responses from five possible answers. Matrix Reasoning is a measure of nonverbal fluid reasoning and general intellectual ability.

The average reliability coefficient for the FSIQ-4 is 0.98 and the test-retest reliability is 0.92.The Inter-rater reliability: 0.98 (Vocabulary), 0.99 (Similarities). The Vocabulary and Similarities subtests compose the Verbal Scale and yield the Verbal IQ, which is a measure of crystallized abilities.

WMS-III Abbreviated

According to Wechsler (2002) the WMS-III Abbreviated is a reliable survey of memory abilities. The WMS-III Abbreviated is used to measure working memory, auditory memory and visual memory in the absence of extended memory testing. The test is administered individually. According to the WMS-III Abbreviated Manual it can be administered in 15-20 minutes by trained examiners and is appropriate for use with participants aged 16-89 years. However findings from initial pilot studies provided information leading to the removal of the WMS-III Abbreviated as a memory survey. Reasons for the removal of the WMS-III Abbreviated are discussed in Section 2.2.4 below and Power, Kirwan & Palmer (2010) a copy of which is available in Appendix J.

MAC-S

The Memory Assessment Clinics Self-Rating Scale (MAC-S;Winterling, Crook, Salama, & Gobert, 1986) includes 21 ability-to-remember items, 24 items assessing frequency of occurrence of memory failures, and 4 global rating items (see Appendix D). The five ability factors include Remote Personal Memory, Numeric Recall, Everyday Task-Oriented Memory, Word Recall/Semantic Memory (with a secondary representation of Reading Recall), and Spatial and Topographic Memory. The five Frequency of Occurrence factors comprise Word and Fact Recall or Semantic Memory, Attention/Concentration, Everyday Task-Oriented Memory, General Forgetfulness, and Facial Recognition. These items are scored on a five point Likert scale. According to Crook and Larrabee (1990) the advantages of the MAC-S include the brevity of the scale, the wide range of memory self-report factors, and a large normative base that covers the adult age range of 18 to 92 years. Furthermore Crook and Larrabee (1992) stated that the MAC-S has high test–retest reliability and concurrent validity; with a factor structure that is deemed extremely stable, minimally

affected by age or sex, which further enhances the research and clinical applications of this scale. A decrease in mean score indicates an improvement in memory.

2.2.4 Pilot Study

Two pilot tests were carried out before the study commenced. The first participant was male aged 82 years. During testing the participant exhibited signs of fatigue and distress. When asked, the participant responded that the WMS-III Abbreviated was "very tiring". The participant appeared in distress and asked to withdraw from study. In the second pilot the female participant aged 73 years completed the WMS-III Abbreviated. However the time taken to finish was approximately one hour; three times longer than the time specified by the WMS-III Abbreviated Manual. The second pilot participant commented that the WMS-III Abbreviated was difficult and tiring.

The pilot studies yielded important information regarding the application of the WMS-III Abbreviated with elderly participants. Three key flaws observed were that it was tiring, it was overly long and it caused distress. More details of this pilot study are discussed in Power, Kirwan & Palmer (2010) a copy of which is available in Appendix J.

Due to these findings the WMS-III Abbreviated was deemed inadequate for use with adults aged over 65 years in this study. A suitable alternative memory scale was sought. The Memory Assessment Clinics Self-Rating Scale (MAC-S;Winterling, Crook, Salama, & Gobert, 1986) was chosen as an alternative. All other scales, tests and materials were found to be suitable and no other changes were made.

2.2.5 Procedure

From April 2009 until May 2010 the researcher attended a total of 13 meetings with Active retirement groups, U3A groups, elderly exercise groups and individuals. Groups were attended in the inner city, north, south and county Dublin encompassing populations with differing degrees of wealth, socio economic status and education. The researcher talked to approximately 545 people from these groups (see Appendix K). Seventy people agreed to take part in the study with 30 of those dropping out. Forty participants finished the study, four in group one, seven in group two, fourteen in group three and fifteen in group four.

The researcher organised meetings with groups of older adults in order to introduce himself and state the purpose of the research; the researcher was looking for adults over the age of 65 to use either a technological or text-based cognitive skills training tool for a period of two months. In some cases a research assistant was present. Groups were made aware that pre and post testing would be required. The researcher then took phone numbers from individuals expressing interest. Following these meetings prospective participants were contacted in order to describe details of what participation would involve. The researcher then organized to meet with interested participants in order to administer testing and provide instruction on the use of the cognitive skills training tool.

Participants were administered the screening questionnaire (Appendix A) to establish the level at of technology usage and whether the participant had used either intervention on a regular basis before the study.

Eligible participants were asked to read and sign consent forms (including assurance of full anonymity and confidentiality) in some cases participants did not understand or could not read the consent form. In these situations the researcher or assistant read the consent form to the participant to ensure full disclosure. Participants were then given the numerical ability test (see Appendix C) to complete followed by the MAC-S (see Appendix D). Lastly the WASI was administered.

The intervention category was determined through the participant date of birth required on the consent form. Participants born in January, March, May, July, September and November were assigned to the Nintendo DS *Brain Training* group and participants born in any other month were assigned to the text book *Brain Training* group. Participants were asked to spend 5-10 minutes each day using either the technological or text-based intervention.

At approximately the 30th day during the intervention period participants were contacted by the researcher in order to find out if the participant was having any problems using either intervention and to ascertain how often the participant was using the intervention. In some cases participants had discontinued use of the cognitive skills training tool without notifying the researcher. These telephone calls gave the researcher a chance to assess which participants had dropped out and which participants would finish the study.

Following the sixty day intervention period, post-tests were conducted with all participants. Post-testing consisted of a satisfaction questionnaire (see Appendices E & F), the numerical ability test, MAC-S and the WASI. During post testing the researcher noted any comments relating to either intervention. At the end of the post tests participants were

thanked and given a participant debrief. Participants were then informed that focus groups would be taking place in the near future and asked if they would like to be contacted in order to take part. Focus groups were conducted with representative participants from each group following the study. The report on these focus groups is available in Chapter Four.

2.2.6 Ethical Concerns

There were a number of ethical concerns associated with this study. These include: confidentiality, anonymity and informed consent. The data was treated with full anonymity and confidentiality. The ethical statement on the consent form (Appendix B) assured participants that their data would be kept confidential and that they would not be identifiable in the final report. Participants were given pseudonyms to ensure anonymity and any correspondence with the participants could only be accessed via a password known only to the researcher.

Each consent form was preceded by a statement outlining the aims of the study (See Appendix B). This statement also indicated to participants that they were free to decline to answer any question, withdraw from the study at any time, or refuse to take part from the beginning, without any negative consequences. At the end of the document, there is a declaration and a check box. By ticking the box, the participant agreed to voice recording during testing.

Participants were given participant debriefs (Appendix G). The participant debrief outlines the aims of the study and provides contact information for the researcher and supervisors. Furthermore contact information for older adult support groups, Alzheimer's and the dementia society were provided for participants.

Great care was taken to ensure ethical care was taken both of participants and the researcher. Wherever possible meetings were held with participants in open public areas such as a library. In some cases when asked the researcher would conduct testing in a participant's home. Where possible the researcher would bring an assistant to ensure that participants were treated with consideration and respect, and also to ensure the safety of the researcher.

2.2.7 Conclusion

The focus of this section was to describe the methodology that was used in order to investigate the research question and hypotheses. The next section describes the results from the study.

2.3 Results

This section describes the statistics used to understand the results of the older adults study. The results of the numerical ability test, the MAC-S, the WASI, the satisfaction scores and likelihood of finishing the study are presented.

2.3.1 Numerical Ability Test

Table 2.6 describes the mean scores and standard deviations for the pre and post numerical ability scores.

Table 2.6: Numerical Ability Trial (NAT) Pre and Post Test Scores

Condition	Mean Scores pre-test (seconds)	Std. Deviation pre	Mean Score post-test (seconds)	Std. Deviation post
1 Ds			84.5	18.52
2 Book			94.71	36.78
3 Pre tested DS	139.21	57.40	103.42	40.71
4 Pre tested Book	127.86	52.22	96.86	37.22

To investigate the effect of the intervention condition on NAT scores a one way between–subjects ANOVA was conducted. The mean scores are presented in seconds; a decrease in mean score indicates an improvement in NAT score. Results indicated that there was not a statistically significant effect of pre-testing on the NAT post test score: ($F(3,36) = 0.294$, $p = .829$, partial $\eta^2 = 0.24$). Furthermore A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the numerical ability test. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change

between post-test numerical ability scores: $F(1,13) = 0.640$, p=.438, partial $\eta^2 = 0.04$. However there was a significant effect of the presence of either intervention to decrease the time take to complete the Numerical ability test: $F(1,13) = 36.13$, $p < 0.0005$, partial $\eta^2 = 0.735$. Although there was not a significant interaction between either intervention on NAT scores: $F(1,13) = 0.537$, $p = 0.477$, partial $\eta^2 = 0.040$. In summary there was a significant difference on the numerical ability test scores following use of either intervention (DS/book). There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores. Table 2.7 illustrates the numbering system for within-subjects factors.

Table 2.7: Illustration of the Numbering System for Within-Subjects Factors

Factor 1	Intervention			
Levels	DS		Book	
Factor 2	Testing		Testing	
Levels	Pre	Post	Pre	Post
Conditions	(1,1)	(1,2)	(2,1)	(2,2)

2.3.5 MAC-S Total Score

Table 2.8 describes the mean scores and standard deviations for the pre and post MAC-S total scores.

Table 2.8: MAC-S Total

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 Ds			124.5	12.15
2 Book			122.57	7.06
3 Pre tested DS	126.42	10.6	127.14	9.63
4 Pre tested Book	123.66	14.19	125.06	10.92

In order to investigate the effect of the intervention condition on the MAC-S total post test score a one way between–subjects ANOVA was conducted. Results indicated that there was not a statistically significant effect of pre-testing on the on post test scores: ($F(3,36) =$

0.341, p = .795, partial η^2 = 0.28). Furthermore A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the MAC-S total score. A 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores: F(1,13) = 0.051, p=.825, partial η^2 = 0.004. There was not a significant effect of the presence of either intervention to increase MAC-S Total score: $F(1,13) = .287$, p = 0.601, partial η^2 = 0.022 . There was not a significant interaction between either intervention on MAC-S Total Score: $F(1,13) = 0.018$, p = 0.896, partial η^2 = 0.001. In summary there was not a significant difference on the MAC-S total scores using either intervention. There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores.

2.3.6 MAC-S part A Global Items

Table 2.9 describes the mean scores and standard deviations for the pre and post MAC-S part A global items total scores.

Table 2.9: MAC-S Part A Global Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 Ds			13.25	3.30
2 Book			10.42	1.39
3 Pre tested DS	11.35	2.02	11.71	1.97
4 Pre tested Book	11.33	2.41	11.06	3.03

A one way between–subjects ANOVA indicated that there was not a statistically significant effect of pre-testing on the on the MAC-S part A global items score: ($F(3,36)$ = 1.249, p = .306, partial η^2 = 0.094). Furthermore a 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the MAC-S part A. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores: F(1,13) = 0.014, p=.909, partial η^2 = 0.001. There was not a significant effect of the presence of either intervention to increase MAC-S part A score: $F(1,13) = .062$,

p = 0.807, partial η^2 = 0.01. There was not a significant interaction between either intervention on MAC-S part A score: $F(1,13) = 0.712$, p = 0.414, partial η^2 = 0.05. In summary there was not a significant difference on the MAC-S part A scores using either intervention. There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores.

2.3.7 MAC-S part B Ability to Remember Items

Table 2.10 describes the mean scores and standard deviations for the pre and post MAC-S part B ability to remember items.

Table 2.10: MAC-S part B Ability to Remember Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 DS			61.25	8.13
2 Book			62.14	7.24
3 Pre tested DS	63.57	10.32	65.64	9.82
4 Pre tested Book	65.20	13.62	65.46	9.59

A one way between–subjects ANOVA indicated that there was not a statistically significant effect of pre-testing on the on MAC-S part B ability to remember items score: ($F(3,36) = 0.445$, p = .722, partial η^2 = 0.036). A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the MAC-S part B. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores: F(1,13) = 0.133, p=.722, partial η^2 = 0.01. There was not a significant effect of the presence of either intervention to increase MAC-S part B score: $F(1,13) = .465$, p = 0.507, partial η^2 = 0.035. There was not a significant interaction between either intervention on MAC-S part B score: $F(1,13) = 0.381$, p = 0.548, partial η^2 = 0.028. In summary there was not a significant difference on the MAC-S part B scores using either intervention. There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores.

2.3.8 MAC-S part C Frequency of Occurrence Items

A one way between–subjects ANOVA indicated that there was not a statistically significant effect of pre-testing on the on the MAC-S part C frequency of occurrence items score: ($F(3,36) = 0.045$, $p = .987$, partial $\eta^2 = 0.004$). A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the MAC-S part C. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores: $F(1,13) = 0.314$, $p=.585$, partial $\eta^2 = 0.024$. There was not a significant effect of the presence of either intervention to increase MAC-S part C score: $F(1,13) = .003$, $p = 0.956$, partial $\eta^2 = 0.00$. There was not a significant interaction between either intervention on MAC-S part C score: $F(1,13) = 0.983$, $p = 0.340$, partial $\eta^2 = 0.070$. In summary there was not a significant difference on the MAC-S part C scores using either intervention. There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores. Table 2.11 describes the mean scores and standard deviations for the pre and post MAC-S part C frequency of occurrence items total scores.

Table 2.11: MAC-S part C Frequency of Occurrence Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 DS			50.00	19.04
2 Book			50.00	3.60
3 Pre tested DS	51.50	11.09	49.78	10.85
4 Pre tested Book	47.13	11.19	48.53	11.65

2.3.9 WASI Total Score

A one way between–subjects ANOVA indicated that there was not a statistically significant effect of pre-testing on the on the WASI Total score: ($F(3,36) = 0.951$, $p = .426$, partial $\eta^2 = 0.073$). A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the WASI 4 subset. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores:

F(1,13) = 0.172, p=.685, partial η^2 = 0.01. However there was a significant effect of the presence of either intervention to improve scores on the WASI total score: $F(1,13) = 6.142$, p = 0.028, partial η^2 = 0.32. There was not a significant interaction between either intervention on WASI Total scores: $F(1,13) = 0.19$, p = 0.892, partial η^2 = 0.01. In summary there was a significant difference on the WASI total scores following use of either intervention (DS/book). There was no significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did not significantly affect scores. Table 2.12 describes the mean scores and standard deviations for the pre and post WASI 4 subset total scores.

Table 2.12: WASI Total

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 DS			225.00	27.21
2 Book			237.85	25.86
3 Pre tested DS	233.00	25.13	243.42	26.75
4 Pre tested Book	234.93	30.20	245.66	15.39

2.3.10 WASI Performance Subtest

A one way between–subjects ANOVA indicated that there was not a statistically significant effect of pre-testing on the WASI performance score: ($F(3,36) = 0.067$, p = .977, partial η^2 = 0.01). A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the WASI Performance subtest. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test scores: F(1,13) = 0.224, p=.644, partial η^2 = 0.01. There was not a significant effect of the presence of either intervention to improve scores on the performance subtest of the WASI: $F(1,13) = 3.99$, p = 0.067, partial η^2 = 0.23. However this result approaches significance. There was not a significant interaction between either intervention on WASI Performance scores: $F(1,13) = 0.049$, p = 0.828, partial η^2 = 0.004. In summary there was not a significant difference on the WASI performance scores following use of either intervention (DS/book). There was no significant difference found between the text-based and technologically based

tools. Lastly completion of a pre-test did not significantly affect scores. Table 2.13 describes the mean scores and standard deviations for the pre and post WASI performance total scores.

Table 2.13: WASI Performance

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 DS			113.75	16.64
2 Book			113.42	15.28
3 Pre tested DS	109.42	14.97	112.92	19.77
4 Pre tested Book	110.86	8.45	115.40	9.56

2.3.11 WASI Verbal Subtest

A one way between–subjects ANOVA indicated that there was a statistically significant effect of pre-testing on the on the WASI verbal score ($F(3,36) = 3.733$, $p = 0.020$, partial $\eta^2 = 0.237$). A planned comparison revealed that participants from the pretested condition using the Nintendo DS Lite scored significantly higher in WASI verbal score than participants in the non pretested condition using the Nintendo DS Lite ($t = -3.071$, $df = 36$, $p = .004$). The mean scores for the pretested condition using the Nintendo DS Lite = (130.5) which are significantly higher than the mean scores for the non pretested condition using the Nintendo DS Lite condition 1 = (111.25). These results indicate that the presence of a pre-test did significantly affect the WASI verbal item scores leading to an increase in WASI verbal score. Table 2.14 describes the mean scores and standard deviations for the pre and post WASI verbal subtest total scores.

Table 2.14: WASI Verbal

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
1 DS			111.25	14.17
2 Book			124.42	13.58
3 Pre tested DS	123.57	12.30	130.5	9.19
4 Pre tested Book	130.93	10.76	130.33	10.65

The following planned comparisons did not reveal a statistically significant difference of WASI verbal items scores between:

Condition 3 and 4 (t = -0.41, df = 36, p = .968).
Condition 2 and 4 (t = 1.167, df = 36, p = .251).
Conditions 1 and 2 (t = -1.902, df = 36, p = .065).

However as results indicate participants from condition 1 and 2 approach significance. This indicates that participants using the Nintendo DS scored higher than participants using the book. A 2*2 within-subjects ANOVA design was employed to investigate if the presence of a pre-test combined with the intervention category influenced scores on the WASI Verbal subtest. The 2*2 within-subjects ANOVA indicated that there was a significant change between post-test scores leading to an increase in WASI Verbal scores: $F(1,13) = 5.985$, $p=0.029$, partial $\eta^2 = 0.31$. There was a significant effect of the presence of either intervention to improve scores on the WASI total score: $F(1,13) = 6.307$, $p = 0.026$, partial $\eta^2 = 0.32$. There was a significant interaction between interventions on WASI Verbal scores: $F(1,13) = 0.9885$, $p = 0.008$, partial $\eta^2 = 0.43$. There was a significant difference on the WASI verbal subtest scores using either intervention (DS/book). Participants using the technological intervention showed more improvement on WASI Verbal scores than participants using the text-based intervention.

In summary there was a significant difference on the WASI performance scores following use of either intervention (DS/book). There was a significant difference found between the text-based and technologically based tools. Lastly completion of a pre-test did significantly affect scores.

2.3.12 Satisfaction Scores

Table 2.15 describes the mean score, standard deviation and range of the post-test satisfaction scores for the technological and text-based intervention groups altogether.

Table 2.15: Satisfaction Scores

Condition	Mean Score post-test	Std. Deviation post	Range
DS	28.72	6.48	13-35
Book	24.54	5.03	10-32

Satisfaction scores were higher in the technological intervention group (mean = 28.72) taken as a whole than in the text-based intervention group (mean = 24.54) taken as a whole. The mean difference between the conditions was 4.06 and the 95% confidence interval for the estimated population mean difference is between .49 and 7.86. The effect size was large (d=5.714). An independent t-test showed that the difference between conditions was significant (t = 2.294, df = 38, p=0.027, two tailed). Figure 2.5 illustrates the sample difference between the sample means for both conditions.

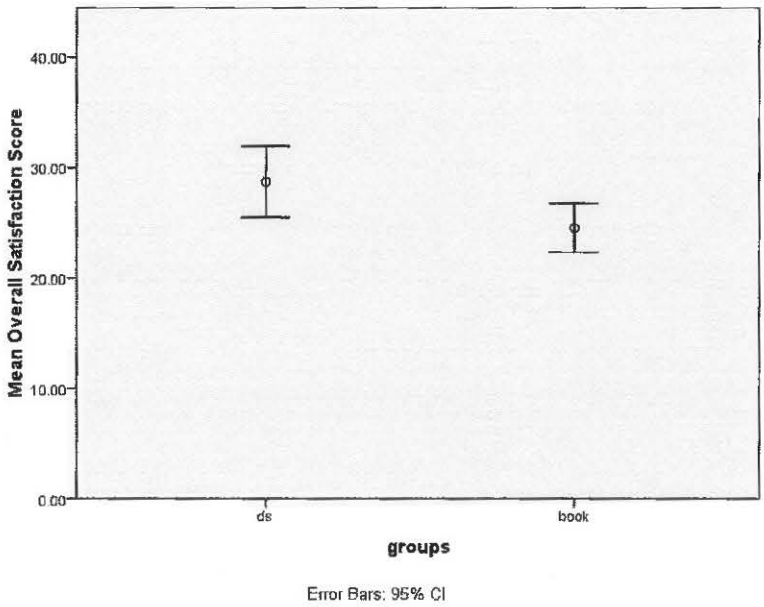


Figure 2.5: Satisfaction Scores Comparison of Means

2.3.13 Completion of Study

A chi-square analysis was completed to investigate the effects of intervention condition on the likelihood of finishing the study.

Table 2.16 describes the count, expected count, percentage within condition, percentage finished and overall percentage for participants finishing the study for both conditions (DS/book).

Table 2.16: Participants Finishing Study Based on Condition

Finish	DS yes	DS no	Book yes	Book no
Count	18	11	22	19
Expected Count	16.6	12.4	23.4	17.6
% within condition	62.1	37.9	53.7	46.3
% finished	45.0	36.7	55.0	63.3
% of Total	25.7	15.7	31.4	27.1

Figure 2.6 illustrates the difference in participants finishing the study based on condition.

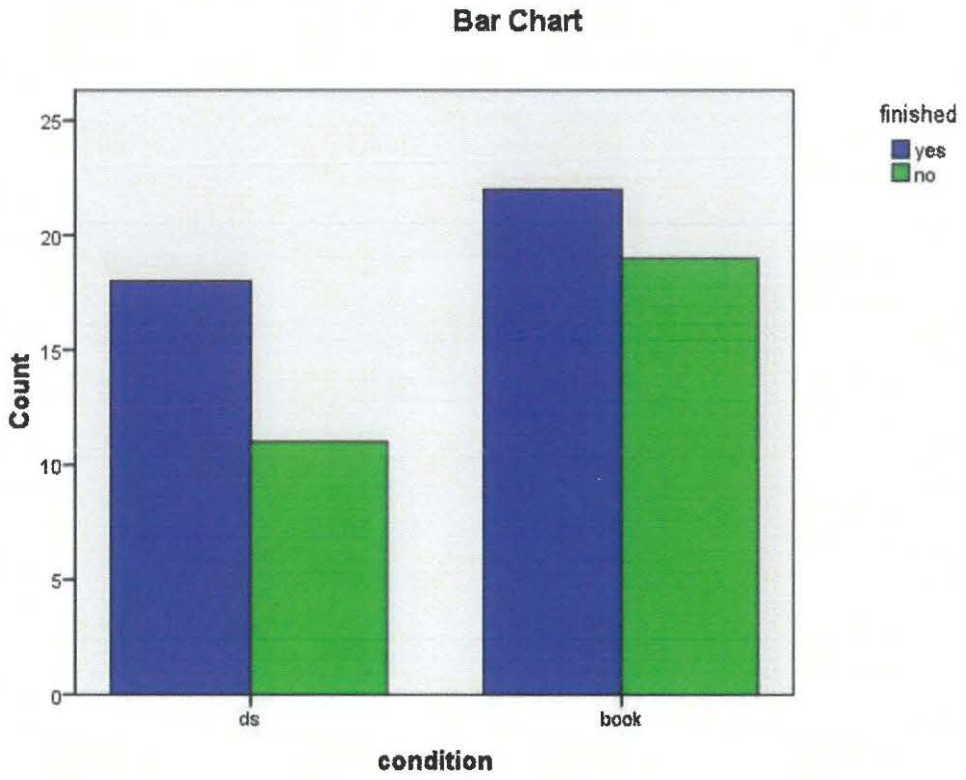


Figure 2.6: Participants Finishing Study Based on Condition

There was no relationship between condition (DS/book) and the likelihood of finishing the study: $\chi^2(1, N = 70) = 491$, $p = .484$. This result indicates that condition did not have an effect on whether a participant finished the study or not.

Likelihood o Finishing Study

A chi-square analysis was performed to investigate the effect of pre-testing on the likelihood of finishing the study. Table 2.17 describes the count, expected count, percentage within condition, percentage finished and overall percentage for participants finishing the study for both categories (pre-test/ non pre-test).

Table 2.17: Breakdown of Pre-Tested Participants by Condition

Finish	DS Pre-test yes	Book Pre-test no	DS Non Pre-test	Book Non Pre-test
Count	19	25	10	16
Expected Count	18.2	25.8	10.8	15.2
% within condition	43.2	56.8	38.5	61.5
% finished	65.5	61.0	34.5	39.0
% of Total	27.1	35.7	14.3	22.9

Figure 2.7 illustrates the difference in participants finishing the study based on testing category (pre-test/non pretest).

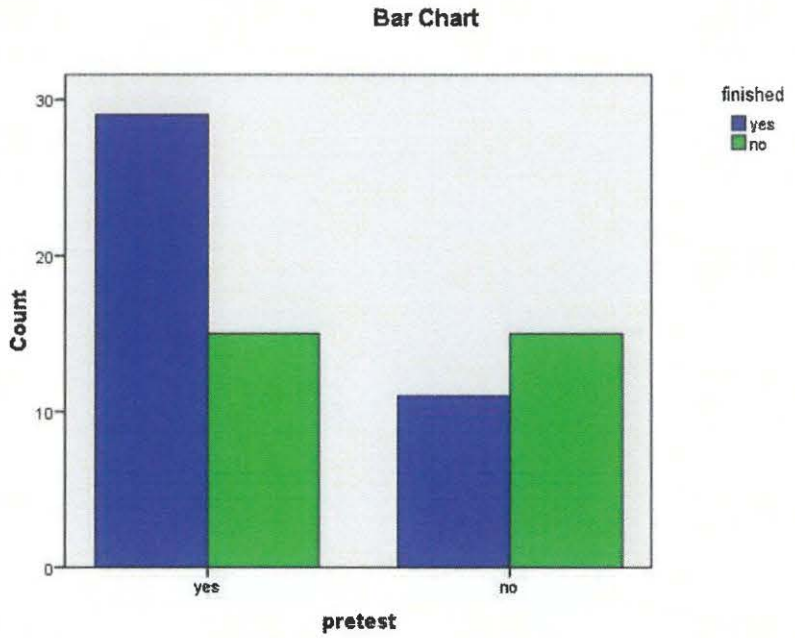


Figure 2.7: Participants Finishing Study Based on Pre/non Pre-Test

There was no relationship between testing category (pre-test/ no pre-test) and the likelihood of finishing the study: $\chi^2(1, N = 70) = .150$, $p = .698$. This result indicates that testing category did not have an effect on whether a participant finished the study or not. To view the SPSS data output for the older adults study see Appendix L.

2.4 Discussion

2.4.1 Introduction

This section will discuss the findings of the study with regard to the literature. The discussion begins with an explanation of the results in relation to the hypotheses, followed by other interesting findings which emerged. The discussion continues with an outline of the limitations and implications of the study, concluding with recommendations for future study.

2.4.2 Hypotheses

Numerical Ability Test Scores

The first hypothesis stated that the use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test. Results indicated that there was a significant improvement on numerical ability scores following use of either intervention. This finding supports claims made by Kawashima (2005) that using *Brain Training* tools are an effective way of increasing numerical ability. These results are similar to those of Owen et al (2010). Owen et al (2010) found that participants improved using online cognitive training on tests of their specifically trained tasks.

The numerical ability test was designed based on the arithmetic worksheets from Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Part of the basis for Dr Kawashima's *Brain Training* is that solving arithmetic problems quickly may lead to positive transfer to other cognitive functions. This point will be discussed further with relation to intelligence and memory.

The fifth hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools. Results indicated that there was not a significant difference in improvement in NAT scores between the different conditions (DS/book). This finding would suggest that there is no difference between using the test or technology based tools on NAT scores. This suggests that older people can use text or technology based tools without a difference in NAT score.

MAC-S

The second hypothesis stated that the use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S). Results indicated that there was not a significant improvement on the MAC-S Total score, MAC-S part A, MAC-S part B or MAC-S part C following use of either intervention.

These results run contrary to results from the ACTIVE study. Initially Schaie and Willis (1986) used training in memory skills to endeavour to reverse cognitive decline in older adults. Improvements were indicated in adults whose cognitive abilities had not declined prior to the training and also in those whose cognitive abilities had weakened. The findings of the current study in relation to memory also contrast with the ACTIVE results from Langbaum (2009). This study indicated that adults gravitate toward specific mnemonic techniques. Memory training employed during the ACTIVE study included learning mnemonic strategies. Participants involved in the current study did not train in specific mnemonic strategies. Langbaum (2009) also suggested that the degree of plasticity varies from person to person which could explain the lack of improvement in memory training. However as the MAC-S is a self report measure of memory it is difficult to compare the results of the current study to previous studies conducted using standardized psychometric tests. Participants may not have perceived improvements in their own memory. The results indicate that there was not an improvement noticed by participants not that there was not an improvement in memory. Use of a standardized psychometric test of memory could produce different findings.

The sixth hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools. Results indicated that there was not a significant effect of the intervention condition on the MAC-S Total score, MAC-S part A, MAC-S part B and MAC-S part C following use of either intervention. The result suggests that participants did not report experiencing a significant improvement following use of either intervention. However the MAC-S is a self report measure and the results could have been different had an alternative memory test been used.

WASI

The third hypothesis stated that the use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Wechsler Abbreviated Scale of Intelligence (WASI). Results indicate that there was a significant improvement on WASI Overall score following use of either intervention.

This finding supports results from the Uchida and Kawashima (2008) study. Similar to Uchida and Kawashima (2008) participants improved significantly on tests of intelligence. Uchida and Kawashima (2008) observed improvements in lexical fluency indicating self organised retrieval from semantic memory. This can be compared to the vocabulary and similarities subtest of the WASI. In this way the current research supports findings from the Uchida and Kawashima (2008) study.

Conversely the findings from the current study contradict results from Owen et al (2010). Owen et al (2010) did not support the use of computerized cognitive skills training in order to enhance cognitive functioning. Benchmark testing conducted included tests of reasoning, verbal short term memory, spatial working memory and paired associates learning. The WASI measures a number cognitive abilities similar to the test used by Owen et al (2010) such as verbal reasoning learning, visual information processing, abstract reasoning skills, the ability to analyze and synthesize abstract visual stimuli, visual perception and organization, simultaneous processing and visual-motor coordination. These can be compared to the WASI. However the current research with older adults found contrasting results with regard intelligence. Regardless of the type of *Brain Training* tool used (text or technology) significant improvements on WASI scores were observed. The mean age of participants involved in the Owen et al (2010) study was considerably younger (39.14 to 40.51 years) than participants in the current study which could also explain the contrasting findings.

The seventh hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by the WASI compared with the technological based cognitive skills training tools. No significant difference on the WASI overall scores were discovered using either intervention (DS/book). However completion of a pre-test did significantly affect scores. The WASI performance subtest did not yield any significant findings however the WASI Verbal subtest did. Pre-tested participants using the technological intervention showed more improvement on WASI Verbal scores than pre-tested participants using the text-based intervention. This finding indicates that there is partial support for *Brain Training* tools improving intelligence scores. Both fluid and crystallized intelligence are trained by the WASI Verbal subset. This finding indicates that verbal

intelligence and more precisely crystallized intelligence were improved significantly more through use of the technological intervention as opposed to the text-based intervention.

As a difference in change in the WASI verbal subtest was observed between the technological and text-based interventions hypothesis seven was supported. Participants using the technological intervention showed more improvement on verbal intelligence than participants using the text-based intervention. Previous studies of cognitive training programs have indicated that both text based (Uchida & Kawashima, 2008) and computerized (Smith et al., 2008) cognitive training programs can lead to significant improvements in targeted and non-target cognitive functions. The current study indicates that technology based *Brain Training* can improve verbal intelligence to a greater degree than text-based skills training tools.

Satisfaction Scores

The fourth hypothesis stated that the participants will exhibit a preference towards either the technology or text based cognitive skills training tool. An independent t-test found that when taken as a whole participants using the technological intervention scored significantly higher on satisfaction scores than participants using the text-based intervention. Therefore hypothesis four was supported as participants exhibited a preference in satisfaction scores toward the technological skills training tool.

2.4.7 Effects of Pre-testing

The effects of pretesting were found to have a significant effect on one of the WASI subsets and on satisfaction scores. The presence of a pre-test was found to significantly influence scores in a positive manner on the WASI Verbal subset and for satisfaction scores. This effect can be likened to the Hawthorne effect (McGarney, Warner, Iliffe, VanHaselen, Griffin & Fisher, 2007). The Hawthorne effect is a term referring to the tendency of some people to work harder and perform better when they are participants in an experiment. Individuals may change their behaviour due to the attention they are receiving from researchers rather than because of any manipulation of independent variables. This would be consistent with the findings from the current study.

2.4.8 Methodological Problems

In order to understand why hypotheses 5 and 6 were not supported it is practical to consider some methodological problems arising from the study. Participants were randomly assigned a condition and had no choice over which cognitive skills training they would receive. Participants were then asked to use either tool each day for ten minutes. Participants were not supervised daily. The researcher contacted participants roughly four weeks after commencing participation in order to assess any problems and to ask if the participant had been using the tool regularly. Other than this there was very little supervision of participants for the two month period unlike the Kawashima et al (2005) study.

The current study differs from the Kawashima et al (2005) research in several ways. Participants consenting to take part in the study all appeared cognitively healthy, participants were asked to use either intervention for 10 minutes a day for a period of just two months, participants were assessed using different research methods (Solomon four group design) and different measures. The current research could be said to mirror the real world more than Kawashima's (2005) study and in this way Kawashima's (2005) study could be said to lack ecological validity.

2.4.9 Limitations of the Current Research

There were a number of limitations of the current research. Participants were not asked to disclose cognitive or physical health information regarding themselves to the researcher. Participants were not asked to disclose this information due to privacy. However in some instances participants informed the researcher after consenting to take part in the study that they suffered from a specific illness or condition such as in one instance Parkinson's disease. The researcher allowed the participants to take part if the participant still wanted to take part. In another instance a participant could not use the Nintendo DS due to dexterity problems but had no problem using a pen and paper. It is hard to quantify how these cases affected the study as in both cases the participants finished the research. Larger group sizes and more equal group sizes could have lead to more generalizable results. The validity of the MAC-S as a memory test could be questioned as it is a self report measure. Another memory scale could yield different findings if used in place of a self report measure. Participants were mainly recruited from active retirement or university of third age groups.

These participants are interested in learning and further education. In this way it is hard to say the participants are indicative of the overall population of people aged over 65 years.

2.4.10 Implications of the Current Research

As numerical ability and intelligence scores were found to improve after use of the *Brain Training* tools this research supports the validity of *Brain Training* as an aid to cognition. Satisfaction scores indicated that participants preferred to use the technological tool. However no improvement was indicated in the testing on memory. As was previously stated this could be accounted for by the self-report measure used. As *Brain Training* games, books and websites are growing in popularity it is important to try to measure if there are quantifiable improvements from using *Brain Training* tools. Results from this study suggest that use of either *Brain Training* tool can significantly increase numerical ability and verbal intelligence.

2.4.11 Suggestions for further Research

This research adds to the small amount of research conducted in the field of *Brain Training* both in an Irish context and with older adults. The research paves the way for further study in the field, and points out some methodological problems that may arise. The increasing number of internet based *Brain Training* websites could be investigated. Further research could be conducted using a longitudinal design to investigate the use of *Brain Training* tools into old age. A longitudinal study could investigate further into the research conducted by Kawashima (2005) indicating that *Brain Training* can slow the onset of dementia. Another area warranting further research is that of primary school aged children. *Brain Training* has been shown to improve numerical abilities in primary school aged children. An investigation of how long these improvements last and if the children go on to do better in academia than students not using *Brain Training* tools could yield important results. There is also the need for qualitative research to be conducted to investigate the perceptions and attitudes of the users of *Brain Training* tools. This type of research is crucial to understand the perceptions, wants and needs of the users of *Brain Training* tools. A number of issues raised by participants from this study were found to warrant further

investigation. Hence focus groups were conducted with members of the groups. These focus groups are discussed in Chapter Four.

2.5 Conclusion

The Dr Kawashima's *Brain Training*: How Old Is Your Brain Instruction manual (Nintendo, 2006) suggests that "training can help boost your memory". According to Kawashima (2007) through use of one of these interventions the user can "help people retain mental clarity and stave off the mental effects of aging" (p. 3) obtain increased cognitive functioning or a better memory. These claims are supported to a certain extent by the current study as there was a significant improvement found in adults aged over 65 in numerical ability and verbal intelligence. Claims that using *Brain Training* can lead to a better memory however were not supported. This could be due in part to the fact that a self report measure of memory was employed and a standardized psychometric test of memory could yield different findings.

The current study supports the use of *Brain Training* as an aid to help to increase numerical ability and verbal intelligence. The literature review identified gaps in the research on cognitive skills training with older adults. This study built upon previous literature but also investigated the use of cognitive training presented on different platforms. On the whole participants did experience significant positive change in numerical ability and intelligence. However there was no difference found between using the text and technological tool. The following chapter will examine the use of cognitive skills training tools by undergraduate third level students.

Chapter 3

A Study of Third Level Students using Text-Based and Technology Based Skills Training Tools

3.1 Introduction

This chapter describes the methodology, results and discussion of the quantitative research conducted with third level students. The aim of this section of the research was firstly to investigate the effect of cognitive skills training tools on intelligence, memory and numerical ability in third level students. Secondly the aim of the research was to investigate the difference between using a text-based cognitive skills training tool and a technologically based cognitive skills training tool. Thirdly the aim was to investigate the attitudes of third level students concerning cognitive skills training. The following hypotheses were investigated:

H8 The use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test (NAT).

H9 The use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S).

H10 The use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Raven's Standard Progressive Matrices (SPM).

H11 Participants will exhibit a preference towards either the technology or text based cognitive skills tool.

H12 The use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools.

H13 The use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools.

H14 The use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by the Raven's SPM compared with the technological based cognitive skills training tools.

By investigating these research questions and hypotheses it will be possible to formulate results that are comparable to the older adults research discussed in Chapter Two.

This allows for comparisons across age groups that can yield salient information regarding cognitive skills training tools.

3.2 Methodology of the Research

3.2.1 Design

In order to choose an appropriate experimental design method to investigate this topic a number of different designs were considered. A qualitative design such as an interview or case study can provide rich data on one or more participants using the text based or technological cognitive skills training tool (Robson, 2002). In order to investigate hypotheses 8, 9, 10, 12, 13 and 14 studying quantifiable improvements in cognition a quantitative method was deemed more appropriate. In order to investigate hypothesis 11 (participants will exhibit a preference towards either the technology or text based cognitive skills tools) both qualitative and quantitative design methods were used. The qualitative design chosen was that of focus groups referred to in more detail in Chapter Four. Other qualitative designs such as an observation study or case study were deemed inappropriate due to time constraints and the intrusive nature which could distress participants. In this way both quantitative and qualitative designs were used in a complementary fashion.

A two group pre-test/post-test experimental design was chosen in order to determine which intervention demonstrated the greatest improvement in third level students' cognitive abilities. In this experimental design, one group was exposed to a technological intervention and another group was exposed to a text-based intervention (Robson, 1993, pp. 89-90). Participants were recruited into one of two groups; group five (technological aid) or group six (text aid) see Table 3.1. Unlike the study of older adults discussed in Chapter Two, all third level students were pre and post tested.

Table 3.1: Two Group Pre-test/Post-test Experimental Design

	Intervention Used	Pre-Test Included
Group 5	Technological	Yes
Group 6	Text-based	Yes

3.2.2 Participants

Participants were recruited using purposive sampling. Robson (2002) describes purposive sampling as that which allows a researcher to judge whether a particular population are of interest and allows the researcher to satisfy the specific needs of a project. The population of interest studied were third level students aged 18 to 65 years. A third level institute was contacted in order to source participants. A lecturer consented to allow the research be carried out with students from a psychology course. Students from the course were contacted and asked to participate in research counting as part of a continuous assessment project. Students had the right not to participate in the study, and could choose to do an alternative assignment if they wished.

Table 3.2: Age Ranges by Condition

Condition	Mean Age	Range	Std. Deviation	n
5. DS	24.43	20.00 - 62.00	10.06	16
6. Book	21.72	21.00 - 23.00	.64	11

Participants were not asked explicitly about any health or mental health diagnosis. Screening questionnaires (see Appendix A) were given to participants in order to assess the level of technology use and to assess whether participants had used either the technological or the text-based intervention prior to testing. Table 3.2 describes the overall age range of participants as 20 to 62 years. The pre-tested DS condition (condition 5) consisted of 16 participants aged between 20 and 62 years (m = 24.43 years, sd = 10.06). The pre-tested book condition (condition 6) consisted of 11 participants aged between 21 and 23 years (m = 21.72 years, sd = .64). Figure 3.1 describes the age range of each condition: condition 1(range= 42 years) and condition 2 (range = 2 years).

Figure 3.1 illustrates that the mean age of the pre-tested technological intervention condition and the female participants was increased significantly by the presence of one female participant aged 62 years. The total mean age of all participants was 23.33 (sd = 7.77).

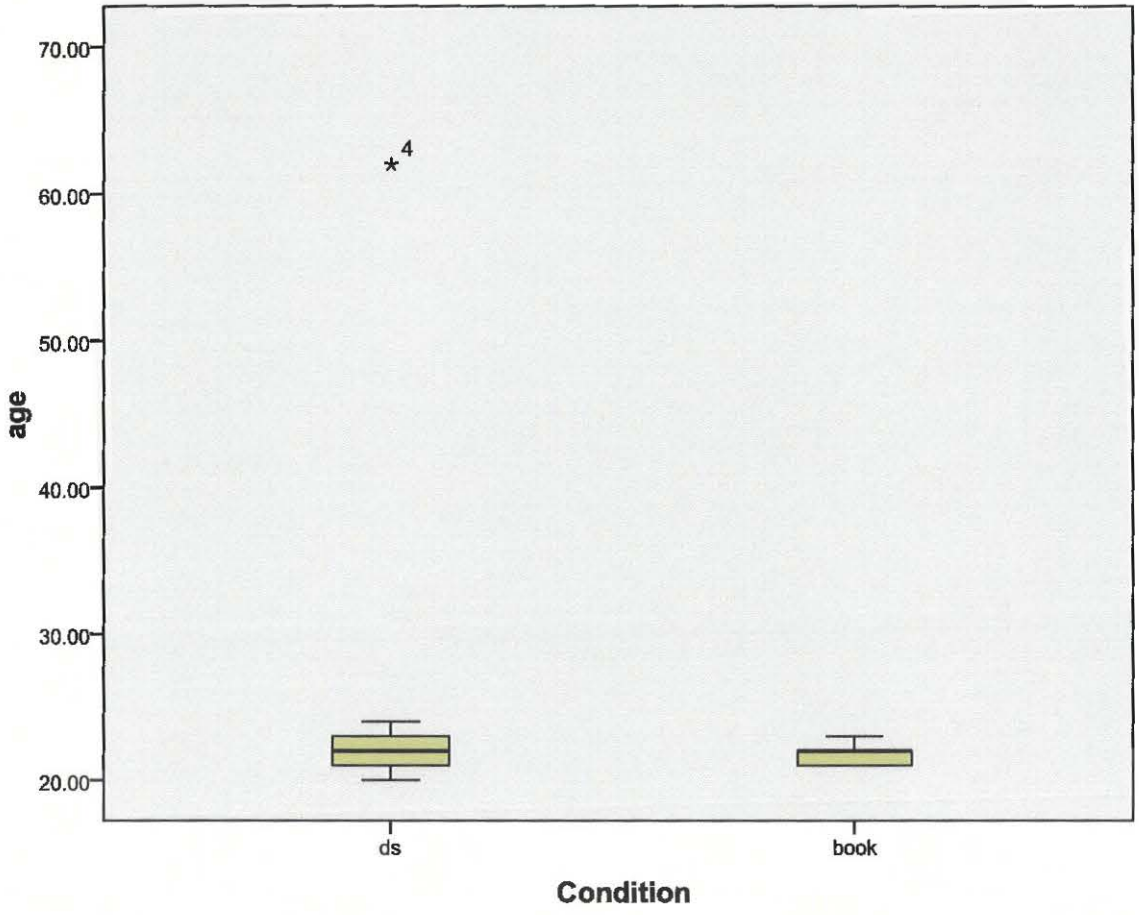


Figure 3.1: Age Range and Condition

Twenty seven students consented to take part in the study. No participants dropped out.

Table 3.3 describes the age and gender of participants, 10 female participants (m = 25.9 years, sd = 12.70) and 17 male participants (m=21.82, sd = .951). The frequency of participants is described as female (37%) and male (63%).

Table 3.3: Age and Gender of Participants

	Frequency	Percent	Mean Age	Std. Deviation	Min – Max
Female	10	37	25.9	12.70	21-62
Male	17	63	21.82	.951	20-24
Total	27	100	23.33	7.77	20-62

Figure 3.2 describes the age range of female participants (21-62 years) and the age range of male particpants (20–24 years).

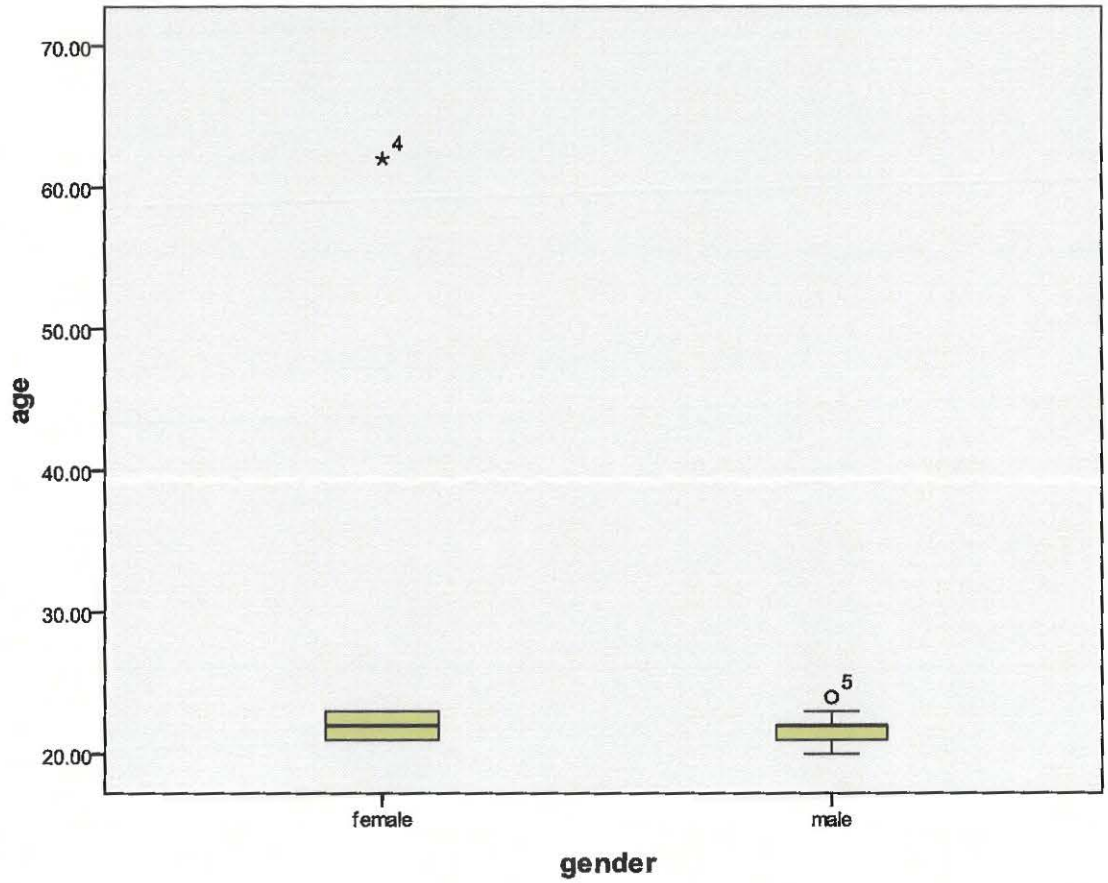


Figure 3.2: Gender and Age Range

Table 3.4 presents a breakdown of the conditions by gender. The DS condition consisted of an equal number of females and males whereas the pretested book condition consisted of mostly male participants.

Table 3.4: Breakdown of Conditions by Gender

	DS	%	Book	%
Female	8	50	2	18
Male	8	50	9	82

3.2.3 Materials

A technological and text based intervention, screening questionnaire, consent and debrief forms and a number of pre and post tests were sourced and created. The technological intervention consisted of the temporary provision of a Nintendo DS Lite Games Console and a copy of the game *Dr. Kawashima's Brain Training: How Old is Your Brain.* The text-based intervention consisted of a similar alternative developed by the same neuroscientist - Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*".

Consent forms (see Appendix M) and questionnaires (see Appendix N) were created by the researcher. Pre-tests and post-tests consisted of a short test of numerical problem-solving abilities (Appendix C), Raven's Progressive Matrices and The Memory Assessment Clinics Self-Rating Scale (MAC-S) see Appendix D. Participants were then asked to complete a short post-test questionnaire (Appendices E & F) determining level of satisfaction with the intervention they received. Finally participants debriefs were administered (Appendix O). In order to gain additional qualitative data, focus group questions were created by the researcher for use in focus groups as described in Chapter Four.

Screening Questionnaires

Screening questionnaires (see Appendix N) were created by the researcher to establish both the participant technology usage and whether the participant had used either intervention on a regular basis before the study. Survey questions were asked about; general activities, the Nintendo DS Lite console, use of Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*"; internet, e-mail, word processing and computer management. Participants

were asked to rate the level of confidence in their ability to complete each task along a five point Likert scale for example:"Access an Internet site via its website address", "Do Crossword or Word Search", "Played Dr Kawashima's Brain Training". The screening questionnaire also provided some demographic information including gender and age.

Consent Form

A consent form was developed for use with participants (see Appendix M). Participants were informed of the aims of the study and what taking part would entail. All participants were informed that all data obtained would be treated with full anonymity and confidentiality and no individual participant would be identified if published. This statement also indicated to participants that they were free to decline to answer any question, withdraw from the study at any time, or refuse to take part from the beginning, without any negative consequences. Participants were given pseudonyms to ensure anonymity and any participant information could only be accessed via a password known only to the researcher. At the end of the document there is a declaration; by signing the ethical statement the participant is giving informed consent to take part in the study.

Raven's Standard Progressive Matrices (SPM)

The WASI was found to be inappropriate for use with the student population as there was limited class time to administer tests. A suitable alternative was found to be Raven's Standard Progressive Matrices (SPM) which allows all students to be self tested with paper and pencil simultaneously. Raven's SPM is a test of observation skills and clear-thinking ability. It offers insight about a participant's ability to observe, solve problems, and learn. The test has a total of 60 items presented in five sets (A–E), with 12 items per set. The booklet comprises five sets (A-E) of 12 items each (e.g., A1 through A12), with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyze information. All items are presented in black ink on a white background. There is no time limit for Raven's SPM. Raven's SPM can be used for developmental purposes in occupational and educational settings. The nonverbal aspect of each test minimizes the impact of cultural or language bias. The Raven's SPM produces a single raw score as well as percentile rank or grade to indicate the candidate's educative ability or the ability to think clearly and extract meaning out of events, compared to a norm group. According to Raven, Raven and Court (2000) on analysis of over 40 studies dealing with the reliability of Raven's SPM, the overall account is of good reliability, whether in terms of internal consistency or retest reliability.

The Nintendo DS Lite Games Console, *Brain Training* game, *Brain Training* book, Numerical Ability Trial and MAC-S were identical to those used in the older adult study, and are described in Chapter Two, Section 2.3. Apart from Raven's SPM all other scales, tests, materials were similar to those mentioned in Chapter Two, Section 2.

3.2.4 Procedure

A third level institute was contacted with regard to sourcing participants. A lecturer consented to allow the research be carried out with students from a psychology course. Students from the course were contacted and asked to participate in research counting as part of a continuous assessment project. Twenty seven undergraduate students agreed to take part in the study. Twenty seven participants finished the study, sixteen in technological intervention group and eleven in the text-based intervention group.

The researcher organised meetings with students during class time in order to state the purpose of the research; the researcher was seeking students who would use either a technological or text-based cognitive skills training tool for a period of one month. Students were made aware that pre and post testing would be required. The researcher then organized to meet with the two groups that comprise the class in order to administer testing and provide instruction on the use of the cognitive skills training tool.

Screening questionnaire (Appendix N) were administered to establish both the level at which the participant uses technology and whether the participant had used either intervention on a regular basis before the study.

Participants were asked to read and sign consent forms (including assurance of full anonymity and confidentiality). Participants were then given the numerical ability test (see Appendix C) to complete followed by the MAC-S (see Appendix D). Lastly the Raven's SPM was administered.

As the class was divided into two groups the intervention category was matched to groups randomly, using a coin toss. Students from group five were assigned to the Nintendo DS *Brain Training* group and participants from group six were assigned to the text book *Brain Training* group. Participants were asked to spend 5-10 minutes each day using either the technological or text-based intervention.

Following the six week intervention period, post-tests were conducted on all participants. Post-testing consisted of a satisfaction questionnaire (see Appendices E & F),

numerical ability test, MAC-S and the Raven's SPM. During post testing the researcher noted any comments relating to either intervention. At the end of the post tests participants were thanked and given a participant debrief (Appendix O). Participants were then informed that focus groups would be taking place in the near future and asked would they like to be contacted in order to take part.

Focus groups were conducted with representative participants from each group following the study. For more information on these focus groups see Chapter Four.

3.2.5 Ethical Concerns

There were a number of ethical concerns associated with this study. These include: the right not to participate, confidentiality, anonymity and informed consent. The research study was presented to the students by their lecturer as part of a continuous assessment project. Participants that did not want to take part in the study were given the option of another assignment that would count as part of the continuous assessment project. In this way there were no negative consequences for students who did not want to take part in the research. The data was treated with full anonymity and confidentiality. The ethical statement on the consent form (Appendix M) assured participants that their data would be kept confidential and that they would not be identifiable in the final report. Participants were given pseudonyms to ensure anonymity and any correspondence with the participants could only be accessed via a password known only to the researcher.

Each questionnaire (See Appendix N) was preceded by a statement outlining the aims of the study. This statement also indicated to participants that they were free to decline to answer any question, withdraw from the study at any time, or refuse to take part from the beginning, without any negative consequences. By signing the declaration at the end of the document the students consented to take part in the research.

Participants consenting to take part in the study were given participant debriefs following post testing. The participant debrief outlined the aims of the study and provided contact information for the researcher and supervisors.

Ethical care was taken both of participants and the researcher. All contact with students during initial meetings and testing was conducted in lecture halls with the lecturer present.

3.2.6 Conclusion

The focus of this section was to describe the methodology used in order to investigate the research question and hypotheses. The next section describes the results from the study.

3.3 Results

This section describes the statistics used to understand the results of the student study. The results of the numerical ability test, the MAC-S, the Raven's SPM and the satisfaction scores are presented.

3.3.1 Numerical ability test

Table 3.5 below describes the mean scores and standard deviations for the pre and post numerical ability test scores.

Table 3.5: NAT Pre and Post Test Scores

Condition	Mean Scores pre-test (seconds)	Std. Deviation pre	Mean Score post-test (seconds)	Std. Deviation post
5 DS	121.68	17.58	88.00	23.62
6 Book	127.18	36.39	83.36	24.66

The mean scores are presented in seconds; a decrease in mean score indicates an improvement in NAT score. A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the numerical ability test. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between post-test numerical ability scores: $F(1,10) = 0.005$, $p=.944$, partial $\eta^2 = 0.001$. However there was a significant effect of the presence of either intervention to decrease the time take to complete the Numerical Ability Test: $F(1,10) = 42.974$, $p < 0.0005$, partial $\eta^2 = 0.811$. There was not a significant interaction between either intervention on NAT scores: $F(1,10) = 0..668$, $p = 0.433$, partial $\eta^2 = 0.063$. In summary there was a significant difference on the numerical

ability test scores following use of either intervention (DS/book). There was no significant difference found between the text-based and technologically based tools. Table 3.6 illustrates the numbering system for within-subjects factors.

Table 3.6: Illustration of the Numbering System for Within-Subjects Factors

Factor 1	Intervention			
Levels	DS		Book	
Factor 2	Testing		Testing	
Levels	Pre	Post	Pre	Post
Conditions	(1,1)	(1,2)	(2,1)	(2,2)

3.3.2 MAC-S Total Score

Table 3.7 describes the mean scores and standard deviations for the pre and post MAC-S total scores.

Table 3.7: MAC-S Total

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	138.37	8.81	126.66	9.70
6 Book	134.63	4.22	128.54	10.06

A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the MAC-S total score. A 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: $F(1,10) = 0.325$, $p=.581$, partial $\eta^2 = 0.031$. There was not a significant effect of the presence of either intervention to increase MAC-S Total score: $F(1,10) = 9.150$, $p = 0.13$, partial $\eta^2 = 0.478$. There was not a significant interaction between either intervention on MAC-S Total Score: $F(1,10) = 2.172$, $p = 0.171$, partial $\eta^2 = 0.178$. In summary there was not a significant difference on the MAC-S total scores using either intervention (DS/book). There was no significant difference found between the text-based and technologically based tools.

3.3.3 MAC-S part A Global Items

Table 3.8 describes the mean scores and standard deviations for the pre and post MAC-S part A global items total scores. A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the MAC-S part A. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: $F(1,10) = .157$, $p = 0.700$, partial $\eta^2 = 0.015$. There was not a significant effect of the presence of either intervention to increase MAC-S part A score: $F(1,13) = .062$, $p = 0.807$, partial $\eta^2 = 0.01$. There was not a significant interaction between either intervention on MAC-S part A score: $F(1,10) = 0.157$, $p = 0.700$, partial $\eta^2 = 0.015$. In summary there was not a significant difference on the MAC-S part A scores using either intervention. There was no significant difference found between the text-based and technologically based tools.

Table 3.8: MAC-S part A Global Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	14.43	3.11	14.46	3.27
6 Book	13.45	2.76	13.45	2.76

3.3.4 MAC-S part B Ability to Remember Items

A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the MAC-S part B. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: $F(1,10) = 0.12$, $p=.915$, partial $\eta^2 = 0.001$. There was not a significant effect of the presence of either intervention to increase MAC-S part B score: $F(1,10) = 4.523$, $p = 0.059$, partial $\eta^2 = 0.311$. However this finding approaches significance indicating that the presence of an intervention improved scores on MAC-S part B ability to Remember Items. A decrease in mean score indicates an improvement in memory. There was not a significant interaction between either intervention on MAC-S part B score: $F(1,10) = 0.105$, $p = 0.753$, partial $\eta^2 = 0.010$. In summary there was not a significant difference on the MAC-S part B scores using either intervention. There was no significant difference found between the text-based and technologically based tools.

Table 3.9 describes the mean scores and standard deviations for the pre and post MAC-S part B ability to remember items.

Table 3.9: MAC-S part B Ability to Remember Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	72.37	11.84	67.33	10.76
6 Book	71.54	5.37	68.27	7.19

3.3.5 MAC-S part C Frequency of Occurrence Items

Table 3.10 describes the mean scores and standard deviations for the pre and post MAC-S part C frequency of occurrence items total scores.

Table 3.10: MAC-S part C Frequency of Occurrence Items

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	51.56	10.72	44.86	9.97
6 Book	49.63	7.14	45.27	6.40

A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the MAC-S part C. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: $F(1,10) = 0.229$, $p=.643$, partial $\eta^2 = 0.22$. A decrease in mean score indicates an improvement in memory. There was a significant effect of the presence of either intervention to increase MAC-S part C score: $F(1,10) = 19.39$, $p = 0.001$, partial $\eta^2 = 0.660$. There was not a significant interaction between either intervention on MAC-S part C score: $F(1,10) = 1.452$, $p = 0.256$, partial $\eta^2 = 0.127$. In summary there was a significant difference on the MAC-S part C scores using either intervention. There was no significant difference found between the text-based and technologically based tools.

3.3.6 Raven's SPM Score

Table 3.11 describes the mean scores and standard deviations for the pre and post Raven's SPM scores. A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post test scores on the Raven's SPM score. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: F(1,10) = 1.467, p=.254, partial η^2 = 0.128. There was not a significant effect of the presence of either intervention to increase the Raven's SPM score: $F(1,10) = .916$, p = 0.361, partial η^2 = 0.084. There was not a significant interaction between either intervention on Raven's SPM Score: $F(1,10) = 0.222$, p = 0.648, partial η^2 = 0.022. In summary there was not a significant difference on the Raven's SPM scores using either intervention. There was no significant difference found between the text-based and technologically based tools.

Table 3.11: Raven's SPM Scores

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	50.50	4.44	50.86	4.40
6 Book	51.45	5.39	52.72	3.69

3.3.7 Raven's SPM Grade

Table 3.12 describes the mean scores and standard deviations for the pre and post Raven's SPM Grade.

Table 3.12: Raven's SPM Grade

Condition	Mean Scores pre-test	Std. Deviation pre	Mean Score post-test	Std. Deviation post
5 DS	3.25	.774	3.33	.81
6 Book	3.09	.831	2.90	.53

A 2*2 within-subjects ANOVA design was employed to investigate if there was a significant difference between pre and post-test grades on the Raven's SPM Grade. The 2*2 within-subjects ANOVA indicated that the main effect of the intervention category (DS/book) was not significant on the change between pre and post-test scores: F(1,10) =

2.664, p=.134, partial $\eta^2 = 0.210$. The main effect of the presence of a pre-test to improve grades on the Raven's SPM was not significant: $F(1,10) = .132$, p = 0.724, partial $\eta^2 = 0.013$. There was not a significant interaction between intervention and the presence of a pre-test: $F(1,10) = 1.324$, p = 0.277, partial $\eta^2 = 0.117$. In summary there was not a significant difference on the Raven's SPM grade using either intervention. There was no significant difference found between the text-based and technologically based tools.

3.3.8 Satisfaction Scores

Table 3.13 describes the mean score, standard deviation and range of the post-test satisfaction scores for the technological and text-based intervention groups altogether. Satisfaction scores were lower in the technological intervention group (mean = 20.5) taken as a whole than in the text-based intervention group (mean = 22.36) taken as a whole. The mean difference between the conditions was 1.86 and the 95% confidence interval for the estimated population mean difference is between -7.15 and 3.42. The effect size was large (d=5.714). An independent t-test showed that the difference between conditions was not significant (t = -.729, df = 23, p=0.473, two tailed).

Table 3.13: Satisfaction Scores

Condition	Mean Score post-test	Std. Deviation post	Range
5 DS	20.50	5.48	11-30
6 Book	22.36	7.31	11-33

Figure 3.3 illustrates the sample difference between the sample means for both conditions. To view the SPSS Data Output for the student study refer to Appendix P.

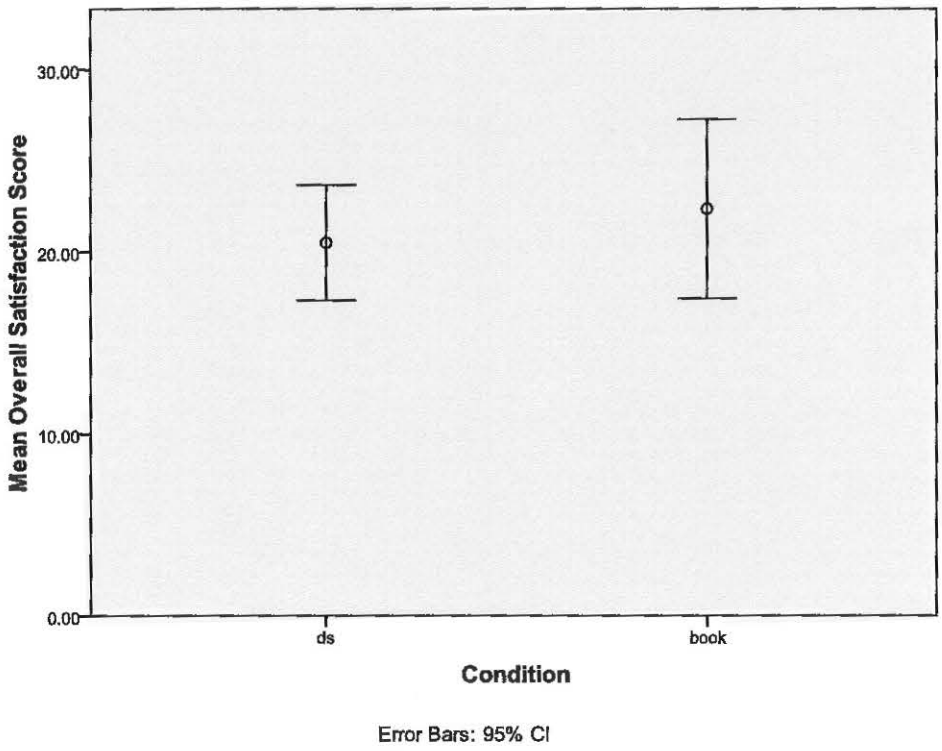


Figure 3.3: Satisfaction Scores Comparison of Means

3.4 Discussion

3.4.1 Introduction

This section will discuss the findings of the undergraduate study with regard to the literature reviewed in Chapter One. The discussion begins with an explanation of the results in relation to the hypotheses and each measure used, followed by other interesting findings emerging from the research. The discussion continues with an outline of the limitations and implications of the study, concluding with recommendations for future study.

3.4.2 Hypotheses

Numerical Ability Test

Hypothesis eight stated that the use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test. Results indicated that there was a significant improvement on the numerical ability test scores following use of either intervention (DS/Book). These results indicate that hypothesis eight was supported.

Again the findings support Kawashima's (2005) claims that using *Brain Training* tools are an effective way of increasing numerical ability. These results also support findings from Owen et al (2010) that cognitive training can improve scores on tests of specifically trained tasks. This finding indicates that cognitive training can increase numerical ability in third level student aged participants (mean age 23.33 years). However this finding does not indicate if there was an improvement in other cognitive functioning such as memory or intelligence. These will be discussed further below.

The 12th hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools. Results indicated that there was not a significant difference in change in NAT scores between the different conditions (DS/Book). This result indicates that participants using the text and technology interventions did not experience different levels of improvements in numerical ability. These results indicated that hypothesis 12 was not supported.

MAC-S

The ninth hypothesis stated that the use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S). Results indicated that there was not a significant improvement on the MAC-S Total score, MAC-S part A and MAC-S part B following use of either intervention. The effect of the presence of an intervention to increase MAC-S part B score was found to approach significance. This could indicate that for ability to remember items the use of *Brain Training* interventions could lead to improvement in self reported memory. A significant improvement was observed with regard to the MAC-S part C frequency of occurrence items. This finding indicates partial support for *Brain Training* tools to improve self reported memory. The results indicate that hypothesis nine was partially supported.

The MAC-S part C results support research from the ACTIVE study by Schaie and Willis (1986). These studies used training in memory skills to reverse cognitive decline in older adults. The findings of the current study also support the ACTIVE results from Langbaum (2009). This study indicated that adults gravitate toward specific mnemonic techniques. Memory training employed during the ACTIVE study included learning mnemonic strategies. Participants involved in the current study did not train in specific mnemonic strategies or were given measures to test for mnemonic strategies. However as the MAC-S is a self report measure of memory it is difficult to compare the results of the current study to previous studies conducted using standardized psychometric tests. Participants may not have perceived improvements in their own memory. The results indicate that there was a partial improvement in self reported memory. Use of a standardized psychometric test of memory could produce different findings.

The 13th hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in memory as measured by the MAC-S compared with the technological based cognitive skills training tools. Results indicated that there was not a significant effect of the intervention condition on the MAC-S Total score, MAC-S part A, MAC-S part B and MAC-S part C following use of either intervention. These results indicate that hypothesis 13 was not supported. This result suggests that there is no difference between using the text and technology versions of *Brain Training*.

Raven's SPM

The tenth hypothesis stated that the use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Raven's Standard Progressive Matrices (SPM). Results indicate that there was not a significant improvement on Raven's SPM score or grade following use of either intervention. These results indicate that hypothesis ten was not supported. This finding presents a contrast to previous *Brain Training* research. Findings from previously mentioned studies such as Uchida and Kawashima, (2008) and Smith et al (2009) indicate improvement on measures of intelligence following *Brain Training*. Again the difference in average age could have impacted the results.

Owen et al (2010) found improvements on online cognitive training tasks trained among participants using cognitive training comparable to commonly available *Brain Training* software. Training included tests of short term memory. Improvements were not observed on cognitive functions not trained. Similar to the Owen et al (2010) findings participants from the current study did not improve on the tests of cognitive functions

(Raven's SPM) that were not directly trained by the intervention. However similar measures were not used on both studies

The 14th hypothesis stated that the use of text based cognitive skills training tools will result in a difference in change in intelligence as measured by Raven's SPM compared with the technological based cognitive skills training tools. No significant difference on the Raven's SPM score or grade was discovered using either intervention (DS/book). These results indicate that hypothesis 14 was not supported.

Satisfaction scores

The 11th hypothesis stated that the participants will exhibit a preference towards either the technology or the text based cognitive skills training tool. There was not a significant difference on the satisfaction score using either intervention (DS/Book). This indicates that participants did not show a preference toward the technology based cognitive skills training tool. These results indicate that the 11th hypothesis was not supported. This result is interesting as according to the literature people aged 16 to 24 years have the highest percentage use of computers and the internet in Ireland (CSO, 2009).

3.4.3 Significance of Findings

Findings from Chapter Two suggested that claims that *Brain Training* can improve cognitive functioning were supported as there was a significant improvement found in adults aged over 65 in numerical ability and intelligence tests. Similar to the older adults study there was a significant improvement found in numerical ability. Partial improvements were observed in memory but no improvement was observed on the intelligence measure. Therefore the findings from this undergraduate study partially support the previous findings of the older adults study. This calls into question the validity *Brain Training* as a cognitive aid for younger adults to improve intelligence. However a number of methodological problems could have influenced the results of the study.

3.4.4 Methodological Problems

In order to understand why hypotheses 10, 12, 13 and 14 were not supported it is practical to consider some methodological problems arising from the study. As with the older adults study discussed in Chapter Two participants were asked to use either the technological

or text-based tool each day for 5-10 minutes. Participants were not supervised daily unlike the Kawashima et al (2005) study. As there was little supervision of the undergraduate participants it is hard to know how often the participants used the tools. It is also difficult to know to what extent participants used the tools according to instructions given. Students were taking part in the research in order to complete a continuous assessment project. Although an alternative assignment could have been completed this may have affected the results. This is unlike the older adults who were taking part for their own reasons.

The current study differs from the research conducted by Kawashima in several ways. Participants consenting to take part in the study all appeared to be both cognitively and physically healthy. The mean age of the dementia patients differed significantly from that of the undergraduate students. There were also methodological differences in the way the patients were tested. Participants were tested with different measures, for a different time frame and using a different intervention. These reasons make comparing the current study with Kawashima's research inappropriate.

3.4.6 Limitations of the Current Research

There were a number of limitations of the current research. Participants were not asked to disclose cognitive or physical health information regarding themselves to the researcher. Participants were not asked to disclose this information due to privacy. Larger group sizes and more equal group sizes could have lead to more external validity. The validity of the MAC-S as a memory test could be questioned as it is a self report measure. Another memory scale could yield different findings if used in place of a self report measure. Participants were recruited from a third level institution. As was previously stated students were participating in the research to fulfil a course related assessment. This limits the external validity of the study as it is unclear how often the students used the *Brain Training* tools. Much of the previous research conducted with *Brain Training* has investigated older adults, or primary school aged students and to a lesser extent middle aged adults. The current study was conducted with mostly young adults. The lack of research into this segment of the population makes drawing comparisons to previous research difficult.

Familiarity of students with psychometric testing measures could have limited the study. Undergraduate students are commonly recruited to participate in research. The

participants used could have had experience with a range of testing measures. This may have decreased the impact of the intervention on the student participants.

It could be misleading to attribute changes on test scores solely to the use of the intervention category. Neither a Solomon design nor a control group were used with the student population. Furthermore practise effects could account for changes observed on test scores with regard the younger population. However the small numbers of students available did not allow for the use of a control group or a Solomon Four group design. Furthermore the most important area of interest was the change in scores between the text and technological intervention groups not the within group score.

3.4.7 Implications of the Current Research

Hypothesis ten stated that the use of cognitive skills training tools will result in a significant improvement in intelligence as measured by Raven's Standard Progressive Matrices (SPM). Hypothesis ten was not formally supported by this research. This suggests that among third level students Brain Training does not improve intelligence. *Brain Training* is based on the theory that reading aloud and performing simple arithmetic activates the prefrontal cortex and that this activation may lead to a positive transfer to other cognitive functions such as intelligence. These results could call into question the efficacy of *Brain Training* to improve intelligence with third level students. This conclusion could be inaccurate as a partial improvement was observed in intelligence among older adults and different measures were used to assess intelligence in the two studies.

Hypothesis nine was partially supported providing some evidence for the effects of *Brain Training* tools to improve memory. Unlike the older adults study satisfaction scores did not indicate that participants preferred to use either *Brain Training* tool. However there was no significant change in scores on any of the measures tested following use of either *Brain Training* tools. As *Brain Training* games, books and websites are growing in popularity it is important to try to measure if there are quantifiable improvements derived from using the *Brain Training* tools. Results from this study suggest that using either *Brain Training* tool does not significantly increase intelligence but can lead to improvements in numerical ability and partial improvement in memory. *Brain Training* tools by and large are aimed at older adults. The implications of using *Brain Training* tools with young adults have been neglected in the literature.

3.4.8 Suggestions for Further Research

This study adds to the small amount of research in the field of *Brain Training* both in an Irish context and with third level undergraduate students. This research paves the way for further study in the field, and points out some methodological problems that may arise. The increasing number of internet based *Brain Training* websites could be investigated. Most research in the area of *Brain Training* is conducted with older adults or primary school age children. More research with third level students could be considered with different types of cognitive skills training tools.

3.5 Conclusion

This chapter presented the undergraduate student study reporting results and discussing the implications of the results. Participants using both interventions obtained a significant improvement in numerical ability. Student participants using both interventions obtained a significant improvement in the frequency of occurrence subset of the MAC-S. Furthermore findings indicated that on Part B of the MAC-S a finding approaching significance was observed on the presence of either intervention to improve scores. However unlike the older adults study improvements were not observed in measures of intelligence. Findings did not indicate a significant difference in change in numerical ability, memory or intelligence between the different conditions (DS/Book). Lastly results indicate that participants using the text and technology interventions did not experience different levels of satisfaction.

This research supports the use of *Brain Training* tools to improve numerical ability and partially improve memory. However the findings do not support the use of *Brain Training* tools to improve intelligence in third level students. A number of issues arose during both studies that warranted further investigation.

During the older adults study a significant number of participants dropped out. Both student and older adult participants also commented on a number of problems concerned with using both *Brain Training* tools. In order to investigate these recurring issues focus groups were performed with participants from each group. The following chapter reports and discusses the focus groups that were performed.

Chapter 4

Focus Groups and Interviews

4.1 Introduction

This chapter describes the methodology, results and discussion of the qualitative research relating to both older adults and third level students. The first aim of this section of the research is to investigate the views, opinions and attitudes held by third level students and older adults regarding *Brain Training*. The second aim is to investigate the reasons for older participants dropping out of the study. The third aim of the research is to investigate the difference between using a text-based cognitive skills training tool and a technologically based cognitive skills training tool. Lastly the aim is to investigate problems encountered by users of the *Brain Training* tools. The fourth and eleventh hypotheses will be investigated: Participants will exhibit a preference towards either the technology or text based cognitive skills tool.

By investigating these research questions and hypotheses it will be possible to gain a greater breadth of understanding concerning the use of the *Brain Training* tools with older and younger adults. This allows for comparisons across age groups that can yield salient information regarding cognitive skills training tools.

4.1.1 Overview of Considered Methodology

In order to choose the most appropriate methodology a number of data gathering methods were considered. The method to be selected as most appropriate to the study depended on a range of factors including the focus of the study, the participants involved and the resources available. The four qualitative research methods considered were observations, questionnaires, interviews and focus groups see Table 4.1. These methods are discussed further below and the rationale for the choice of method will be stated.

Table 4.1: Considered Methodology

Methodology	**Aim**
Observational	Exploring context of user activity
Questionnaires	Answering specific questions
Interviews	Investigating issues
Focus groups	Collecting various perspectives

Robson (2002) describes the observation method as where the researcher watches the participants, records this in some way and then describes, analyses and interprets what has been observed. Observational methods call for heavy investment of time and effort. The mere act of observing use of the *Brain Training* tools could not lead to obtaining salient information concerning attitudes towards the *Brain Training* tools. For this reason the observation method was deemed inappropriate for use in the study

A questionnaire is a written list of questions which a participant reads, interprets and responds to. This method is utilized to gather data from a wide number and range of participants. The response rate for questionnaires however can be low and responses may not be answered sufficiently. As the research was concerned with exploring participant attitudes that may not have been considered previously, the questionnaire method was also deemed inappropriate for use in this part of the research.

Interviews are any person-to-person interaction between two or more people with a specific purpose. An interview that involves a group of participants is commonly known as a focus group. Interviews allow for flexibility as the interviewer can formulate additional questions on the spot and participants can give opinions in a supportive environment that would not be teased out with a different methodology. These reasons highlight the suitability of the interview and focus group methods in the context of the current research.

4.1.2 Focus Group Method Overview

The second type of data-gathering conducted was focus groups. A focus group is a group interview on a specific topic. It is essentially an open ended discussion guided by the researcher or moderator allowing the opportunity for participants to discuss their needs feelings and experiences about a product and to propose alternative ideas and suggestions (Fisk et al., 2004). According to Morgan (1998) the four main stages of the focus group method comprise: (1) Planning (2) Recruiting (3) Moderating and (4) Analysing and Reporting. The focus groups were planned following Morgan's (1998) approach for More Structured Groups whereby the discussion content is controlled by the questions in the script and the group dynamics are controlled by the moderator. According to this approach the aim of the focus group is to keep the group focused on the topic at hand. Questions were developed for the focus groups using Krueger (1998a) Sequence for developing Questions.

This approach is comprised of four stages clarifying the problem, identifying questions, preparing the first draft of questions followed by sharing and revising questions.

4.1.3 Planning the Focus Group/Interviews

Older Adult Drop-out Focus Groups

The purpose of the focus groups was to gain insight into the reasons for early departure from the study and to ask participants' opinions on the *Brain Training* tools. Due to the high dropout rate for this study (42.85%) the researcher thought it important to try to understand older adult participants' reasons for quitting the study. Were the reasons for early departure related to the *Brain Training* tools or were there other outside influences causing the high attrition rate? Areas of particular interest included; reasons for stopping use of the *Brain Training* tool, ease of use problems with the *Brain Training* tool and attitudes towards *Brain Training*, education and technology. This information could then be used to determine the type of *Brain Training* tool that would be most suitable to older adults' needs and preferences and put forward any proposed changes to the *Brain Training* tools. The questions used in the group were formulated using an informal style to ensure the participants felt as comfortable as possible.

Older Adult Completer Interviews

The purpose of these interviews was to gain insight into the reasons participants completed the study. Again due to the high dropout rate it was thought important to understand why these participants continued to use the *Brain Training* tools. The following areas were explored; the role of diligence, ways in which the training tools could be improved, perceived benefits derived from *Brain Training* and attitudes towards *Brain Training*.

Information from both focus groups and interviews can then be used to determine the type of *Brain Training* tool that would be most suitable to older adults' needs and preferences and to put forward any proposed changes to the *Brain Training* tools. The questions used in the group were formulated using an informal style to ensure the participants felt as comfortable as possible.

Student Focus Groups

The purpose of the focus groups was to discuss the needs, feelings and experiences of students that used the *Brain Training* tools. The mean age of students tested was significantly younger than participants from the older adults group. This provided an opportunity to investigate the attitudes of younger adults to both *Brain Training* tools and compare these to that of older adults. However participation of one mature student did increase the mean age of the group significantly. Areas of particular interest were: ease of use problems with the *Brain Training* tools, attitudes toward *Brain Training* and toward older users, problems using the tools diligently, enjoyment and positive aspects of the *Brain Training* tools.

4.2 Participants

Older adults drop-out focus groups

Participants that dropped out of the study before reaching the two month time period were recruited. Participants were contacted by phone and asked to take part in a focus group concerning their participation in the study. Four people consented to take part in the focus groups (two from the technological intervention group and two from the text-based intervention group) and it was discussed what day and time would be appropriate for all involved. The technological intervention drop-out participants consisted of one male and one female with a mean age of 74.5 years. The text-based intervention drop-out participants consisted of two male participants with a mean age of 73 years.

Older adult completer study interviews

Participants finishing the study were recruited and asked to take part in a focus group. Participants were contacted by phone and asked to take part in a focus group concerning their participation in the study. Four people consented to take part in the focus groups (two from the technological intervention and two from the text-based intervention) and it was discussed what day and time would be appropriate for all involved. However on the day of testing only one participant from each group arrived. The researcher therefore conducted individual interviews with one participant from the technological intervention and one from the text-based intervention. The technological intervention participant was female (age: 71 years) and the text-based intervention participant was female (age: 83 years).

Student Focus Groups

Seven participants from the technological intervention group and the text-based intervention group discussed in Chapter Three consented to take part in the focus groups. Participants were contacted during class time and asked to participate in a focus group concerning their use of the *Brain Training* tools. Participants were told where and when the focus groups would take place. The technological intervention focus group consisted of seven participants: four female and three male (mean age: 24.43 years). The text-based intervention focus group consisted of seven participants: six male and one female (mean age: 21.72). All focus group and interviews were held in a third level institute. Table 4.2 illustrates the age and gender of participants taking part in the focus groups and interviews.

Table 4.2: Age and Gender of Participants

Participants	**Intervention Used**	**Female**	**Age**	**Male**	**Age**	**Number of participants**	**Mean Age**
Older adults dropout	Technological	1	70	1	79	2	74.5
Older adults dropout	Text-based	1	77	1	69	2	73
Older adults finishing study	Technological	1	71	0		1	71
Older adults finishing study	Text-based	1	83	0		1	83
Undergrad Students	Technological	4		3		7	24.43
Undergrad Students	Text-based	1		6		7	21.72

4.3 Materials

Scripts

Focus group scripts were prepared for use during all focus groups (see Appendices Q, R, S, T, U & V). The scripts were prepared in order to give the researcher a document to keep each focus group on topic and as similar as possible. Each script began with a section introducing the researcher, the assistant (if present) and explaining the aims of the research. There was then a section of the script explaining the format of the focus group. The last part of the introductory section of the script explained that consent forms must be read and signed in order to participate in the research. The next section was comprised of the focus group script. Questions were developed using Krueger (1998a) Sequence for developing Questions discussed above see section 4.1.2. Lead open questions were asked followed by more focussed prompts. Focus group questions were followed by a conclusion and a participant debrief.

Consent Form

Consent forms were created for use with all participants (see Appendix X). Participants were informed that all data obtained would be treated with full anonymity and confidentiality and no individual participant would be identified if published. The statement given on the consent form indicated to participants that they were free to withdraw from the study at any time without any negative consequences and informed participants that their voice would be recorded. Participants were given pseudonyms to ensure anonymity. At the end of the document, there is a declaration and a check box. By ticking the box, the participant gave informed consent to take part in the study.

Debrief

The participant debrief thanked the participants for taking part in the focus group, provided an account of the aims of the study and provided contact information for the researcher and supervisors (see Appendix X).

4.4 Procedure

Older Adult Drop-Out Focus Groups

Two focus groups were carried out during this section of research. Both focus groups were held in a quiet room with participants seated facing the moderator. The technological intervention focus group took place at 1.00pm and the text-based intervention focus group took place at 2.00pm. Both focus groups lasted approximately 25 minutes. Four people consented to attend the focus groups altogether, two attending the first focus group and two attending the second focus group. The technological intervention focus group consisted of one female and one male participant using the *Brain Training* game. The text-based intervention focus group consisted of two male participants that had been using the *Brain Training* book. Refreshments were offered to the participants on arrival. The moderator read through a prepared script informing participants about the project, the purpose of the focus group, how the focus group would be run, and how the participants' involvement would be of benefit. Participants were then asked to read and sign the consent form before the discussions began.

The focus groups began with the moderator introducing himself and introducing the participants to each other. Questions were put to each group about their reasons for discontinuing use of the *Brain Training* tool, their feelings/attitudes towards *Brain Training*, comments on the *Brain Training* tool and perceived benefits of the *Brain Training* tool. All participants contributed to the study. There was no noticeable gender difference between participants' comments or behaviours.

Older Adult Completer Iinterviews

Two interviews were carried out during this section of research. Both interviews took place in a quiet room with participants seated across a table facing the moderator. The technological intervention interview commenced at 1.00pm and the text-based intervention interview commenced at 2.00pm. Both interviews lasted approximately 20 minutes. Two female participants consented to attend the interviews, one participant attending each interview. Refreshments were offered to the participants on arrival. The moderator read through a prepared script informing participants about the project, the purpose of the interview, how the interview would run, and how the participants' involvement would be of

benefit. Participants were then asked to read and sign the consent form before the discussions began.

The interviews commenced with the moderator introducing himself and the assistant to each participant. Questions were put to each participant about their enjoyment of the *Brain Training* tool, the degree of diligence taken to finish the study, feelings/attitudes towards *Brain Training* and improvements to *Brain Training* tools.

Student Focus Groups

During this section of research two focus groups were carried out. Both focus groups were held in a quiet room with participants seated in a semi circle facing the moderator, the first focus group took place at 11 am and the second at 2.00 pm. Both focus groups lasted approximately 40 minutes each. Seven people consented to attend each focus group. The technological intervention focus group consisted of four females and three males. The text-based intervention focus group consisted of one female and six males. Prior to handing out consent forms the moderator read through a prepared script informing participants about the project, the purpose of the focus group, how the focus group would run, and how the participants' involvement would be of benefit.

The focus groups began with the moderator introducing himself and the assistant. Questions were put to each group about their reasons for what they liked/disliked about the tool, their feelings/attitudes towards *Brain Training*, comments on the *Brain Training* tool and perceived benefits of the *Brain Training* tool. All of the participants contributed to the study. There was no noticeable gender difference between participants' comments or behaviours.

4.5 Analysis

Older Adult Drop-Out Focus Groups

As there was no assistant moderator present during the focus groups to capture relevant notes the type of analysis used was tape based analysis (Krueger, 1998). The audio recordings of the focus groups were transcribed and abridged transcripts containing relevant and useful portions of the discussion were created. A primary analysis was conducted immediately after the focus groups to make sense of written notes while they were still fresh

in the mind. Further analysis involved reviewing the raw data, interpreting the results, categorising similar concepts and allowing themes to emerge.

Older Adult Complete Study Interviews

As there was an assistant present to take notes the type of analysis used was note-based analysis (Krueger, 1998). This relies mainly on notes taken by an assistant during the interview however the audio recordings were transcribed in order to verify quotes and to help contextualize some written points. An initial analysis was carried out immediately following both interviews as in the analysis of the focus groups. Audio recordings were again transcribed in order to formulate abridged transcripts and further analysis involved reviewing the raw data, interpreting the results categorising similar concepts and allowing themes to emerge.

Student Focus Groups

The type of analysis strategy used during this section of research was note-based analysis. This type of analysis relies heavily on field notes taken by the research assistant, debriefing sessions and summary comments made at the conclusion of the focus group. The audio recording of the focus groups were used primarily to verify specific quotes and to verify the oral summary at the conclusion of the focus group. The primary analysis document in note-based analysis is the detailed field notes which can be amplified by other information sources such as the audio recordings. A primary analysis was performed immediately following the focus group to make sense of the written notes and examine findings while they were still fresh in the mind (Krueger, 1998). The audio recordings of the focus groups were transcribed and abridged transcripts containing relevant and useful portions of the discussion were created. Further analysis involved reviewing the raw data, interpreting the results, categorising similar concepts and allowing themes to emerge.

4.6 Moderating

During both focus groups and interviews the researcher acted as moderator. The moderator was responsible for asking questions and guiding the focus groups and interviews. All sessions were recorded using a voice recorder device. The assistant researcher was responsible for note taking.

4.7 Results

This section of the discussion presents the findings of the older adults drop-out focus groups, the older adult completer study interviews and the student focus groups. Initially information is presented concerning the older adults drop-out focus groups. The section continues presenting the findings of the older adult completer study interviews and finally the findings from the student focus groups are presented.

4.7.1 Older Adult Drop-out Focus Group's Themes

The brief notes taken from the group session, including the audio recording, were studied and transcribed. Codes were created in order to identify similar patterns and key points within the discussion (see Appendices Y & Z). Memos were also written to provide meaning and context to the discussion points. This enabled themes and issues to emerge from the raw data. The following themes were found common to both focus groups:

1. Diligence needed to progress further using the game
2. Reasons for quitting the study are related to busy life schedule or family commitments.
3. Ease of use problems
4. Attitudes to *Brain Training*

During both focus groups participants commented on role of diligence or application during *Brain Training*. In order to use either tool on a daily basis for two months commitment is needed. Participants that dropped out of the study recognized that in order to improve they would have needed to use the tools for longer periods of time.

However the reasons given for quitting the study were related to busy life schedules and family commitments not an aversion to using either tool diligently. For one participant caring for a relative made it extremely difficult to try and complete the daily training as the following quote illustrates BP2 "Was interrupted by my wife who has dementia that would break my concentration".

Finding the time to use the *Brain Training* tools was also found to be difficult for another participant GP2"had booked into a lot of courses and was very busy". The participants interviewed all have busy schedules and found it difficult to use the *Brain*

Training tools consistently. These participants were recruited from U3A (The University of Third Age) groups and were busy with U3A meetings, outings and other family commitments such as looking after grandchildren. Among both focus groups and interviews a number of ease of use problems were found with the *Brain Training* tools. The problems noted include

Technological Intervention Problems

- Stroop test problems: "GP2: The Stroop test wouldn't respond and I had to keep shouting at it", "GP2: I'd say black and it wouldn't change".
- Calculations problems: "GP1: I would write a number one but the game would think it was a number seven and I couldn't change it"

Participants experienced problems using the voice recognition software to complete the Stroop test. When using the stylus to write numbers participants found that the game would enter a number that the participant had not intended to write.

Text-based Intervention Problems

- Pages of book turning when not wanted
- No Stopwatch Provided "BP2: I used my phone for a stopwatch."

The pages of the book would easily flip over causing a participant to lose place in calculations when answering timed calculations. This would lead to inaccurate timings when participants were trying to complete calculations as quickly as possible. The book also relies on the participant to produce a stopwatch.

Despite these problems participant attitudes to *Brain Training* were mostly positive. Focus group participants thought the tasks to be "very good" and "stimulating". This positive attitude toward *Brain Training* is evidenced by the following quotes; "GP1: I felt I wasn't making the most of what was on offer.", "GP2: Felt that the training tasks were very good and think that it would help if you kept at it.", "GP1: Something new not just a crossword" "I enjoyed it (using *Brain Training*)". Moreover BP2 went on to suggest that the beneficial effects of transcendental meditation were similar to those of *Brain Training*: "To a degree, I recognise the beneficial effect. I did feel an improvement in alertness *Brain Training* has a similar effect to transcendental meditation." Overall it seems that both participants enjoyed using the book and see *Brain Training* positively.

Both focus groups provided insights into the attitudes and interests of older adult participants. These attitudes and interests included an interest in education, an interest in new

technologies and the way participants' physical ability could differ from their mental abilities. The attitude of participants to education and new technologies was of particular interest. Participants were very interested in continuing education into later life and saw the *Brain Training* tools as an educational aid. Attitudes to new technologies were also revealed. Participants showed an interest and a liking for the new technological tool and not a fear or dislike. Physical problems of older users using *Brain Training* tools were commented on. In this focus group BP1 found that when trying to write answers to the calculation problems he could answer the problems mentally far quicker than he was able to write them: "I can answer the questions quicker in my head than my hand can write them". BP1 commented that this was frustrating "found it frustrating my writing was too slow that frustrated me." Neither *Brain Training* tools take into account the fact that older users may not have the dexterity of younger users.

4.7.2 Identifying Themes Older Adult Completer Interviews

The following themes were found common of both interviews:

1. Using the game did not require a great amount of diligence.
2. Problems using the game
3. *Brain Training* seen as a positive cognitive aid

The brief notes taken from the group session, including the audio recording, were studied and transcribed. Codes were created in order to identify similar patterns and key points within the discussion (see Appendices AA & AB). As with the older adults drop-out focus groups, questions were put to the technological and text-based intervention interviewees about the role of diligence during *Brain Training*. Participant I2 commented that using the book each day did not require great diligence "Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it" and "Didn't find it a chore doing it for research". However participant I2 did comment that "If I say I'll do something I will" and that she had experience with research these factors also contributed to the participant finishing the study. Technological intervention participant I1 later said: "I saw an opportunity to help a researcher with a study and didn't want to commit to something and not follow through" this quote shows that the participant is naturally diligent and follows through with commitments. As this participant enjoyed using the technological intervention

and follows through with commitments it is not surprising that she did not drop out of the study.

A second common theme among the interview participants was that of having a number of ease of use problems with both *Brain Training* tools. Participant I2 commented that the book is monotonous and could be improved by being made more interesting perhaps utilizing a story. Similar to other users participant I2 found the book too tightly bound leading to the book snapping shut when in use "definitely doesn't stay open" and "continually having to squash down the book which takes up extra time". This led to the participant losing their place and taking more time to finish tasks. The idea of a ring binder being used to solve this problem was said to be "ideal". Also an incorporated stopwatch was thought to be a "good idea". The book was found to be easy to use however the participant II did not particularly like using the book "book itself wasn't for me".

A number of problems experienced by the participant using the technological intervention were similar to those of drop out older adult technological intervention focus group. Similar to other comments participant I1 stated the voice recognition was poor and should be improved and also that the reading aloud game was not judged accurately enough: "Make the voice recognition more accurate. Reading aloud wasn't judged accurately enough". The Stroop test and the brain age check were both found to be difficult. Participant I1 commented that it was easy for distractions or fatigue to interfere with the brain age check "Brain age check depending on the day would differ greatly (and) was inconsistent". The tips given in the game were found to be repetitive and of no use.

Thirdly both interviewees considered *Brain Training* positive and beneficial to the older population. Participant I1 initially thought *Brain Training* was "crazy" but with hindsight now thinks it is "very important". Participant I2 also thought that *Brain Training* techniques to be very important for older people and commented that newly retired people could benefit from using it "People would discover they need to keep their brain moving if they talked to someone like you." When asked if there was any difference in telling time and remembering appointments participant I2 commented that she is more alert than before using the book "Should make things register and remember not just write them down. Now I realize it's important to register things in my mind as well as in the calendar."

Participant I2 (text-based intervention condition) believed that it is important for older people to use their brain and to stay mentally active "It's important for older people to use their brain." The benefit of *Brain Training* was felt by participant I1 (technological intervention) so much so that the participant bought their own Nintendo DS to continue

training and also recommended it to friends. Participant I1 did feel benefits from the study but found it difficult to specify "I do feel it helped my memory a bit. Yes but it is hard to be specific". Like many other participants improvements were perceived completing simple calculations.

Contrasting Opinions on Enjoyment

Participants had differing views when asked if they enjoyed using their respective *Brain Training* tools. In the case of text-based intervention participant I2 did not enjoy using the book "I didn't like using it at all". However through using the book participant I2 realized that her memory had deteriorated "the words (word memorization test) made me realize (my) memory was bad, it woke me up". The participant saw this as a positive as she could try to improve her memory. The participant liked the Stroop test similar to most participants interviewed. In contrast participant I1 found using the intervention enjoyable "It was a challenge, and I enjoyed it" liking the calculations "liked the calculations mostly".

4.7.3 Identifying Themes from Student Focus Groups

The brief notes taken from the group session, including the audio recording, were studied and transcribed. Codes were created in order to identify similar patterns and key points within the discussion (see Appendices AC & AD). Memos were also written to provide meaning and context to the discussion points. This enabled themes and issues to emerge from the raw data. Themes that were identified as common to both focus groups include

1. Participants found the tools hard to use on a continuous basis
2. Participants are sceptical of the long term benefits of *Brain Training*
3. Mixed attitudes toward older people using *Brain Training* tools

Participants found the tools hard to use on a continuous basis

The theme of diligence and how often users actually used the *Brain Training* tool was commented on during both focus groups. During the technological intervention focus group participants commented that using the game became GF1: "boring" and GM2:"a task rather than a want" after the initial weeks of training. These comments suggest that using the *Brain*

Training game with diligence was difficult for the students and this could have an effect on scores GM1:"Had to force myself to do the tasks so my score got worse". However participant GM2 commented that as they were using the *Brain Training* game as part of an assignment this could also affect diligence "Something we have to do versus someone buying it for themselves".

Problems using the *Brain Training* book diligently were also revealed during the text-based intervention focus group. Comments were made suggesting that participant BM2 did not like using the book and found it hard to use on a continual basis "Pointless and difficult to keep up on a daily basis, it's repetitive". The following quotes support this claim BM5:"Takes a lot of will to do it every day" and BM5:"There would be an obvious difference if I kept it up". These comments illustrate how participants found the book hard to use diligently but believed that if they had used it every day there would be improvements.

Participants are Sceptical of the Long-term Benefits of Brain Training

During both focus groups more scepticism of the long term benefits was found when compared with the older adult focus groups and interviews. Technological intervention participants commented that there were some benefits from *Brain Training* but that they are hard to quantify and will not last in the future. This statement is justified by the following quotes:

- GF2: "It's hard to know if your memory improves and hard to know if this is a result of the game. Hard to quantify"
- GM2: "There is a benefit but not as great as it could be"
- GM2: "An increase in knowledge base but not memory, you wouldn't have benefited"
- GM2: "It's beneficial, keeping the brain working and active"

On the whole the student group was more sceptical of *Brain Training* than the older adults group. All participants commented that they would not like to try the workbook version of *Brain Training* and if given the chance all would pick the game again.

When participants from the text-based intervention focus group were asked to comment on perceived improvements following the use of the *Brain Training* tool initial answers were overwhelmingly positive. Participants agreed that trying to train your brain is beneficial and commented that they felt an improvement on individual *Brain Training* tasks:

- BM6: "I improved in every part – don't know how you would apply that to real-life"
- BM1: "Good to practice using your brain"

- BM2: "The difference in scores makes you feel sharper, I found myself butting in on people to solve their math problems"

However participants could not agree if this applied outside of the individual tasks or if there was longer lasting improvements BM2: "Get good at tasks individually but difficult to apply to others", BF1: "Have you actually learned the answers or is your brain working to solve the answers" and BF1: "Do you just recognise the questions quicker". Participants agreed that a number of memorization strategies were used during the word memorization tasks BM1: "Use tricks for remembering from primary and secondary school" and BM6: "You develop your own ways of memorising things, e.g. words related to each other". This recall of memorization strategies was found to be of positive benefit.

The last theme found common to both groups was that of mixed attitudes toward older people using *Brain Training* tools. During the technological intervention focus group participant GM2 made the comment that older users might be "put off" by technology whereas others suggested that older relatives are very used to the idea of *Brain Training*. The text-based focus group also provided an insight into the attitudes toward older users of *Brain Training* tools. There were mixed opinions whether older users would prefer to use the text or technological tool. *Brain Training* is seen as not applying to younger people:

- BM6: "Young people ask what are you doing that for? Older people are more enthusiastic about it"
- BM2: "Techniques apply more to older people"
- BM6: "Some adults big into learning new technologies – grandparents are very interested opposed to people of the same age as myself"
- BM1: "Books appeal to older users"
- BM5: "Frustration with technology – older users, throws it away"

The following contrasting themes were found among the groups:

- Enjoyment of *Brain Training* tools
- Positive aspects of the *Brain Training* tools
- Problems encountered using the *Brain Training* tool

Although participants from the technological intervention student focus group did have negative comments about some aspects of the technological intervention, in general the game was said to be fun and enjoyable GM1: "I like the fun aspect, games are easy to follow and enjoyable". Participant GF3 commented that she liked "trying to reduce your times". These positive feelings were not shared by participants from the text based intervention. When asked if the participants enjoyed using the book participant BM5 commented that the book had become a chore to use: "If it becomes a chore, you put it off even though it only takes five minutes". However participant BM6 commented that it was "Satisfying to beat your score" however overall participants did not comment that they enjoyed using the book.

The second theme that showed a clear difference between the groups was that of the positive aspects of the *Brain Training* tools. During the technological intervention student focus group a number of positive attributes were commented on by participants. Participant GM5 commented that the technological intervention was "fun" and "easy to follow". Participant GM3 commented on the interface "The graphic system allows you to see how well you are doing". The incentive system used by the technological intervention whereby a user unlocks more games, the more they use the system was found to be a positive attribute GM1: "The goals make you think about what's coming next, like incentives. Unlocking games as you go along". In contrast to the many positive comments made concerning the technological intervention there were very few positive comments made in relation to the text-based intervention.

The final theme that illustrated the difference between the groups was that of problems encountered using the cognitive skills training tools. With regard to ease of use problems participants commented that the text-based intervention was harder to use the book when tired BF1: "The times of the day matter significantly" and BM4: "Tiredness affects results at night". However in contrast to the older adult focus groups and interviews there were no comments about problems relating to using the book specifically. Participants encountered a number of ease of use problems using the technological intervention similar to problems experienced by older users. The poor voice recognition was found to impact severely on the Stroop test. The speed counting game was found to be GF1: "boring". The brain age was found to change too easily and tips from the Dr Kawashima character were found frustrating by participant GM3 "Kawashima character is like the Microsoft paper clip". Participant GM3 commented that overall the "Game felt very broken at times". The following aspects of the game were negatively commented on:

- Speed counting

  Participant GF1 found this game boring: "Didn't like the counting part, it's boring".

- Voice recognition

  Participant GF2 found the voice recognition software poor and worked sporadically; "Voice recognition is bad - it didn't work well". This caused participant GF3 to avoid using games which asked the participant to speak aloud such as the Stroop test: "Didn't use the speaking option".

- Letter Recognition

  Participant GF1 found that when writing letters on the touch screen a different letter would appear to that which the participant entered: "The answers you wrote were inputted differently – G,K,Y were unrecognised". Participant GF1 found this to affect scores when using the Word Memorization game "Word memorization was ruined". This problem was encountered amongst the majority of participants using the game.

- Tips / Dr Kawashima Character

  A number of tips appear while playing the game informing the user how to use a number of the game's features. The Dr Kawashima character provides the tips and makes comments about what time of the day it is or how frequently a player uses the game. Some of these tips recur so frequently participant GM2 made the comment that when a tip has been received there should be an option to disregard it in future: "May disregard new tips as you get so used to deleting them all the time". As has been previously stated participant GM3 found the Dr Kawashima character annoying: "Kawashima character is like the Microsoft paper clip". Participant GM3 commented that the Kawashima character is "off-putting, should be an option to turn him off".

4.8 Discussion

4.8.1 Introduction

This section will discuss the findings of focus groups and interviews with regard to the literature. This discussion will begin with an explanation of the results in relation to the aims and hypotheses, followed by other interesting findings emerging from the research. The

discussion continues with an outline of the limitations and implications of the study, concluding with recommendations for future study.

4.8.2 Aims

The first aim of this section of the research was to investigate the views, opinions and attitudes held by third level students and older adults regarding *Brain Training*. Older adults' attitudes to *Brain Training* were considerably more positive than student counterparts. In comparison when asked about the perceived long term benefits of *Brain Training* students were more sceptical. Older adult participants did remark more on the positive aspects of both *Brain Training* tools. Older participants made a number of comments regarding the importance of keeping the brain active in the latter years and that they had perceived positive benefits from using the *Brain Training* tools. The student participants did not comment on the importance of keeping the brain active amongst the younger population. Moreover student participants felt that *Brain Training* will not benefit them in the long term. Student participants were also unsure how quantifiable the benefits of *Brain Training* are. Despite these problems attitudes to *Brain Training* were generally positive. Participants commented about the need to keep the mind active and not to become lazy. Participants noted an improved alertness but found it hard to specify what particular benefits *Brain Training* had had. In short older adults believed in the positive effects of *Brain Training* whereas students were more sceptical about cognitive improvements overall.

The second aim was to investigate the reasons for older participants dropping out of the study. Results indicated that participants busy life schedules and family commitments were the main factor leading to discontinuing use of either *Brain Training* tool. This finding is similar to Osterberg and Blaschke (2005) who reported that other priorities and emotional factors were some of the most common barriers to adherence to a medication regime. In relation to the older adults study other priorities included taking care of one's family and attending a number of courses. Emotional factors related to caring for one's family while a family member is sick or caring for a spouse with dementia. Older adults completing the study did not think that diligence played a big role in continuing to participate in the study. However participants reaching completion of the study did suggest that because they were taking part in research they tried to finish the study. This reason for adhering to the *Brain Training* could be viewed as pleasing the researcher also known as the Hawthorne effect

(McGarney, Warner, Iliffe, VanHaselen, Griffin & Fisher, 2007). It is important to note that while a number of problems were mentioned relating to the ease of use of the *Brain Training* tools these were not cited as reasons for poor adherence to the *Brain Training* regime.

In contrast to the older adult drop-out focus groups both older adults completing the study and student participants did not comment on the role of diligence while using the *Brain Training* tools. However participants from the student focus group suggested that the repetitive nature of the training tools caused use to become a chore. As was previously stated participant I2 (older adult completer interview) commented that using the book each day did not require great diligence "Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it". Shatil, Metzer, Horvitz and Miller (2010) found that partial or total lack of adherence can be due to fatigue, other health related limitations, lack of motivation, or to lack of interest in the cognitive training program. A comment from an older adult finishing the study stated that the reason for using the game every day was due to the fact that it was to help out with research. In this way all groups did comment that the tools were hard to use on a continuous basis or that the adherence to the *Brain Training* regime was not related to a desire to use the particular tool. As is stated in the instructions given in both the game and book using the *Brain Training* tools on a continuous basis (everyday for 60 days) is essential to yield a positive benefit. If the user finds the tools difficult to use continually it will be harder to derive benefit from the tools.

The third aim of the research was to investigate the difference between using a text-based cognitive skills training tool and a technologically based cognitive skills training tool. On the whole participants using the *Brain Training* game mentioned many more positive statements compared with participants using the book. It is possible to see the game as a more interesting and dynamic tool compared with the book. Much fewer quotes relating to enjoyment were mentioned about the book. The book is more static with less variety in the types of training tasks to complete. Results from the Survey of Older People and ICTs in Ireland 2008 (Work Research Centre & Age Action Ireland, 2009) would suggest that older participants might gravitate towards a text based tool as only 14.3% of those aged 65-74 years use Information Communications Technologies (ICTs) in Ireland. This survey indicated that older people with higher levels of education use more ICTs than less well educated older users. Older participants were recruited largely from U3A societies in the current study, a society that espouses continuing education for those no longer in full time work. The survey reported that negative attitudes to ICTs include feeling too old to learn and feeling that ICTs are of no practical use to them. However findings from the current study suggest that

participants involved in these focus groups and interviews did not hold these types of attitudes toward the *Brain Training* tools.Overall the *Brain Training* game received more positive feedback then the train your brain book. Participants enjoyed using the game whereas participants using the book found it boring. Participants suggested that incorporating a story could have made the book more interesting.

The fourth aim was to investigate problems encountered by users of the *Brain Training* tools. Problems were found across both groups that related to ease of use with the *Brain Training* tools. A number of problems with the game related to the voice recognition, and number/word recognition software. On a number of occasions participants commented that they could not use games that relied on voice recognition software. Participants across the groups experienced problems when writing numbers and letters on the Nintendo DS touch screen. However not all participants experienced these problems. Inconsistencies were experienced with the brain age check but it is hard to say whether this was down to the game or participant. Problems experienced using the book included the tendency of pages to flip over due to the tight binding and the lack of a stopwatch. Participants found that as the book was tightly bound it was hard to keep pages open. Participants agreed that a spirally bound book would have suited better. The use of a small built in stopwatch was also welcomed by participants.

Problems encountered using the *Brain Training* tools frequently overlapped. The problems encountered using the interventions were mentioned across all groups. In relation to the *Brain Training* game the main problems included voice recognition, letter recognition, speed counting game, tips and the Dr Kawashima character. In relation to the book there were problems with losing one's place as the book was tightly bound and the lack of a stopwatch.

4.8.3 Hypotheses Investigated

The following hypotheses were investigated: H4/H11 Participants will exhibit a preference towards either the technology or text based cognitive skills tool. Among all participants more positive comments were made relating to the technological intervention than the text-based intervention. Shatil, Metzer, Horvitz and Miller (2010) investigated unprompted adherence to a cognitive training program in patients with multiple sclerosis suggested that personalized adaptive feedback is an important aspect with regard promoting adherence. Features of the training program used to achieve adaptive feedback in the study

included using a baseline cognitive evaluation to individualize the training regime, continually adapting difficulty level to the participant, using an interactive adaptive system and lastly providing graphic and verbal feedback after each training task. With regard to *Brain Training* the text-based intervention utilizes a baseline cognitive evaluation, but does not adapt difficulty level to the participant or offer verbal/graphic feedback. The technological intervention follows all three features suggested by Shatil et al (2010) more closely to achieve adherence to the *Brain Training* regime. It is possible to see the game as a more interesting and dynamic tool compared with the book achieving more adaptive feedback. Much fewer quotes relating to enjoyment were mentioned about the book. The book is more static with less variety in the types of training tasks to complete. In light of this information both hypotheses 4 and 11 were supported as participants did exhibit a preference for the technological tool.

4.8.4 Suggestions for further Research

The majority of research conducted in the area of cognitive training are quantitative experimental studies. It is the suggestion of this researcher that more qualitative research be conducted in this area due to the large amount of important data that can be gained by carrying out research such as focus groups and interviews. Focus groups and interviews provide a platform to investigate the strengths and weaknesses of cognitive tools. It is also suggested that studies should investigate cognitive training users over a number of years to investigate if positive benefits gained endure throughout the years.

4.8.5 Limitations of the Current Research

The low numbers of participants attending the older adult focus groups can be viewed as a limitation of the current research. The older adult drop-out focus groups consisted of two participants per intervention group. Furthermore only one of these participants was female. The completer focus groups were only attended by one participant and therefore became interviews. The interview method provides less chance for a spread of opinions and less chance to expand on and tease out answers in comparison to focus groups. Furthermore a focus group script was used with the participants not an interview script. Had the researcher

known prior to the completer interviews a specific interview script may have been formulated for use with participants.

4.8.6 Implications of the Current Research

A number of design aspects of both interventions were found to be problematic for both older and younger users. These include a number of ease of use problems mentioned above. These problems should be taken into account by designers of future *Brain Training* tools. In this way future *Brain Training* tools can meet user needs more readily. This research also found that older people are less averse to using technology then some of the literature suggests. The importance of designing tools that promote adherence to the cognitive training regime is an important aspect of *Brain Training*. *Brain Training* designers should design with adherence to cognitive training in mind.

4.9 Conclusion

The focus groups and interviews provided a platform to investigate a number of interesting findings from the quantitative study. Findings from the older adults study indicated an improvement on measures of numerical ability and verbal intelligence among older adults and an improvement on numerical ability and partial improvement on memory among student participants. However the qualitative research suggests that despite a number of problems encountered using *Brain Training* tools older adults remarked on many positive benefits. In most cases participants found these improvements hard to quantify. However some older participants found using the game enjoyable and beneficial to a point where they wanted to buy their own *Brain Training* tool. Unlike the older adults the undergraduate participants did not deem the *Brain Training* tools as beneficial. Undergraduate participants were more sceptical of the long term benefits of *Brain Training* but did remark upon improvements in numerical abilities. Moreover some undergraduate participants did mention the benefits of using word memorization strategies.

Older adults did seem to find both *Brain Training* tools more beneficial when compared with the undergraduate students. One explanation for this is that cognitive decline is a real possibility for older adults. Relatives, friends and spouses of participants taking part in the study have suffered from decline in cognitive functioning such as dementia and

Alzheimer's. The older adults have more reason to be interested in a tool that endeavours to slow the onset of such decline. A tentative conclusion this researcher suggests is that as the majority of undergraduate students were aged in their early 20's they may not have been as worried about cognitive decline.

The wealth of information gained regarding both focus groups and interviews was vast and provided important insights concerning use of the *Brain Training* tools. Problems encountered by participants during the intervention studies were investigated further by the focus groups and interviews. In this way using mixed research methods strengthened the research findings.

Chapter 5

Discussion

5.1 Introduction

The use of both text and technology cognitive skills training tools have been investigated in a variety of ways during this study; including experimental studies with older adults and students as well as the collection of qualitative data using focus groups and interviews. This final chapter begins by presenting the research questions and giving a general overview of the research. This is followed by a discussion of the hypotheses in relation to the findings from the two intervention studies, the interviews and the focus groups (outlined in Chapters Two, Three and Four). The findings of these studies will be discussed in relation to previous literature. Following this, some strengths and limitations of the current research, implications for *Brain Training* tool development, elderly quality of life and suggestions for further research will be outlined. Finally, an overall conclusion to the research will be presented.

5.1.1 Research Questions

Research Question 1: "*Does using a cognitive skills training tool have a significant effect on numerical ability, memory, and intelligence?*"

Findings from both the older adult and student experimental studies indicated an improvement in numerical ability following use of an intervention. Self report memory was partially improved in the student study but not in the older adult study. With regard to intelligence contrasting findings were observed across the groups. Students did not improve on measures of intelligence whereas older adults showed significant improvement on the verbal intelligence measure. Partial improvement was observed for student participants with regard to memory. In answer to the research question cognitive skills training tools did have a significant effect on numerical ability, intelligence and memory.

Research Question 2: "*What is the difference between using text-based and technology based cognitive skills training tools?*"

Findings from both experimental studies found little difference between using the text-based and technology based training tools. Neither experimental study found a difference in change in score between the two interventions on numerical ability and memory. However the student study did indicate an increased improvement on verbal intelligence following use

of the technological intervention compared with the text-based intervention. This finding indicated a difference between the interventions. Additionally older adult satisfaction scores indicated that the *Brain Training* game was preferred to the book. Finally focus groups and interviews indicated that participants preferred to use the *Brain Training* game. In answer to the research question the findings indicate that the *Brain Training* game can produce a significantly increased improvement on verbal intelligence and is preferable to the *Brain Training* Book.

Research Question 3: "*What attitudes do participants have concerning Brain Training?*"

Focus groups and interviews were carried out with participants to investigate research question three. Findings indicated that older adults believed using *Brain Training* tools was a positive experience. Older adults mentioned improvements after using *Brain Training* but could not quantify exactly what functions had been improved. The text-based *Brain Training* intervention was not viewed so positively. Unlike the older adults the undergraduate participants did not deem the *Brain Training* tools as beneficial. Undergraduate participants were more sceptical of the long term benefits of *Brain Training* but did remark upon improvements in numerical abilities. Similar to the older adults the student participants showed a preference for the technological tool. The rate of attrition was also investigated. Participants indicated that reasons for dropping out of the study were related to busy life schedules and family commitments. Focus group and interview findings indicated a number of problems found using the *Brain Training* interventions. Overall the text-based intervention was viewed more negatively compared with the technology based *Brain Training* intervention.

A number of hypotheses were created in order to explore these questions in detail. These hypotheses are discussed in relation to the findings from Chapters Two, Three & Four.

5.2 Numerical Ability

The first and eighth hypotheses stated that the use of cognitive skills training tools will result in a significant improvement in numerical ability as measured by a numerical ability test (NAT). Results indicated that there was a significant improvement on the numerical ability test scores following use of either intervention among both older adults and students. This indicates that *Brain Training* tools can improve performance on numerical

ability. Kawashima's (2005) team found that primary school age students benefit from this type of *Brain Training*. Both *Brain Training* interventions consist largely of numerical ability tasks. Research by Owen et al (2010) lends support for the claim that *Brain Training* can improve performance on tasks that are specifically trained. Numerical ability is specifically trained in *Brain Training* through calculations tasks. The current research found numerical ability to be improved in both older adult and student participants. The current research supports the use of *Brain Training* to improve numerical ability. As students use simple maths in everyday tasks this could make the lives of primary students easier. The benefits to adults could include daily mathematics tasks such as shopping or budgeting.

However *Brain Training* claims to improve overall cognitive functioning not just numerical ability. To investigate improvements in other areas of cognitive functioning memory and intelligence measures were also tested. This has been the central question of much recent research on cognitive training. This point will be examined further with regard to memory and intelligence later in the section.

The fifth and twelfth hypotheses stated that the use of text based cognitive skills training tools will result in a difference in change in numerical ability as measured by the NAT compared with the technological based cognitive skills training tools. Among both older and younger adults no significant difference on numerical ability score from participants using the text or technology interventions was observed. This finding indicates that neither *Brain Training* intervention produced a more pronounced improvement. The majority of *Brain Training* tools produced today utilize a computerized program presented for internet, computers, portable devices or telephones. This finding could indicate that more text based alternatives to computerized cognitive skills training tools should be produced for older adults who may prefer to use text. However both older and younger adults commented negatively on the text-based tool during focus groups and interviews. Moreover findings from focus groups did indicate that among all groups a preference was indicated for the technological intervention among both younger and older adults.

The preference for the technological intervention should be of interest to future *Brain Training* developers. Literature in the area has concentrated largely on investigations of cognitive training interventions presented either through text or technological means separately. There is little research comparing text and technological cognitive training interventions. This is a strength of the current research as it investigated cognitive training interventions presented in different ways.

5.3 Memory

The second and ninth hypotheses stated that the use of cognitive skills training tools will result in a significant improvement in memory as measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S). Findings from the older adult study did not support hypothesis two. The ninth hypothesis was partially supported by results from the student study. The findings from the older adult study are interesting as they run contrary to much recent research conducted in the area of cognitive training. Cognitive skills training research has indicated significant improvements on generalized measures memory (Smith et al. 2009), mnemonic strategies (Langbaum, 2009), working memory (Uchida & Kawashima, 2008) and other tests of memory. Findings from the student study support the use of *Brain Training* tools to partially improve memory as a significant improvement was observed on MAC-S part C. The MAC-S part C frequency of occurrence items includes word and fact recall or semantic memory, attention/concentration, everyday task-oriented memory, general forgetfulness, and facial recognition. Crook and Larrabee (1992) stated that the MAC-S has high test–retest reliability and concurrent validity; with an extremely stable factor structure, minimally affected by age or sex, enhancing the research and clinical applications of this scale.

A direct psychometric measure of working memory, auditory memory and visual memory, the WMS-III Abbreviated, was originally pilot tested for use in the study. However this test was found to be tiring, overly long and caused distress and was therefore deemed inadequate for use.

Smith et al (2009) used the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998) a direct psychometric measure of memory utilizing list learning, story memory, digit span forward, delayed free recall, delayed list recall and delayed free story recall. The RBANS was used to investigate the effects a cognitive training program on memory and attention in older adults. Smith et al (2009) observed improvements on measures of memory and attention. The findings from the current older adult study do not provide support for the Smith et al (2009) study. Smith et al (2009) however did not use self-report measures of memory. The current research found no improvement on a self-report measure of memory in older adults. The self-report nature of the MAC-S could have impacted this study whereas another psychometric test of memory could have produced different findings

Focus groups and interviews however did indicate some improvements on cognitive functioning among participants. In one instance a participant commented that they felt more alert. In another instance a participant made the comment "I do feel it helped my memory a bit. Yes but it is hard to be specific". Age related cognitive decline is marked by degradations in memory. *Brain Training* claims to slow cognitive decline and lead to improved cognitive functioning. The current research provides support for these claims.

The 6th and 13th hypotheses stated that the use of text based cognitive skills training tools will result in a difference in memory as measured by the MAC-S compared with the technological based cognitive skills training tools. Findings from both the older adult and student studies did not support these hypotheses. The findings suggest that with regard to memory there is no difference between using text-based and technological tools. As was previously stated there is a lack of literature in the area directly comparing cognitive training tools presented through different modalities such as text-based and a technological hand held device.

5.4 Intelligence

The third and tenth hypotheses stated that the use of cognitive skills training tools will result in a significant improvement in intelligence. Intelligence was measured using the Raven's Standard Progressive Matrices (SPM) in the student sample and the Wechsler Abbreviated Scale of Intelligence (WASI) in the older adult sample. The third hypothesis was supported among the older adult study, however the tenth hypothesis was not supported among the student population. Findings from the older adult study lend support for the effect of *Brain Training* to improve intelligence and cognitive functioning among older adults similar to findings from Uchida and Kawashima (2007) and Jaeggi, Buschkuehl, Jonides and Perrig (2008). Uchida and Kawashima (2007) observed improvements in executive functioning after participants took part in cognitive training.

Jaeggi, Buschkuehl, Jonides and Perrig (2008) observed significant fluid intelligence improvements following training involving a demanding working memory task. The current study with older adults supports the finding that intelligence scores can be improved following cognitive training. This could indicate a benefit to overall cognitive functioning. The bulk of research in this area has been conducted with older adults usually over 65 years rather than with student age participants. Owen et al (2010) conducted a six week online

study finding improvements on tasks trained but no transfer effect to untrained tasks. Similar to Owen et al (2010) students in the current study did not improve in untrained tasks such as Raven's SPM or the MAC-S. However there is little similarity between the current research and the study conducted by Owen et al (2010). Student participants recruited for the current study were mostly young adults whereas participants involved in the Owen et al (2010) study were mainly of middle age. Perhaps *Brain Training* could have less of an effect with younger participants as there has been less time for age related decline to degrade cognitive function.

A possible confounding variable is the difference between intelligence measures between the older adult and student groups. The Wechsler Abbreviated Scale of Intelligence (WASI) includes four subtests Vocabulary, Block Design, Similarities and Matrix Reasoning. The intelligence assessment used with older adults is a one-to-one measure taking approximately 40 minutes to complete. Whereas the Raven's Standard Progressive Matrices is self administered test of observation skills and clear-thinking ability similar to the matrix reasoning section of the WASI. The difference in intelligence tests may have impacted results. Further research could investigate memory using the WASI with third level students to address this variable.

The 7th and 14th hypotheses stated that the use of text based cognitive skills training tools will result in a difference in intelligence. Intelligence was measured using the Raven's Standard Progressive Matrices (SPM) in the student sample and the Wechsler Abbreviated Scale of Intelligence (WASI) in the older adult sample. No significant difference on the Raven's SPM was observed. This result indicates that for the student study hypothesis 14 was not supported.

Unlike the student study older adult participants showed partial improvement in verbal intelligence. Furthermore participants using the *Brain Training* game improved to a significantly greater extent than those using the text based intervention. This result indicates that for the older adult study hypothesis seven was supported.

The findings suggest that there is partial support for the use of *Brain Training* tools to improve intelligence in older adults. Moreover there is support for the use of technological *Brain Training* tools to improve verbal intelligence to a greater degree than text-based *Brain Training* tools. Furthermore the focus groups and interviews discussed in Chapter Four indicated that participants prefer the technological intervention. This could indicate that with regard to improving intelligence and in the broader sense cognitive functioning in older adults, cognitive training tools should be presented on technological platforms. As was previously stated there is a lack of literature in the area directly comparing cognitive training

tools presented through different modalities such as text-based and a technological hand held device.

5.5 Satisfaction

The 4th and 11th hypotheses stated that the participants will exhibit a preference towards either the technology or the text based cognitive skills training tool. There was not a significant difference on the satisfaction score among student participants using either intervention however there was a significant difference on satisfaction scores among older adult participants. Findings indicated that when taken as a whole participants using the technological intervention scored significantly higher on satisfaction scores than participants using the text-based intervention. Among the older adult participants hypothesis four was supported as a preference was indicated toward the technological intervention. Among the student participants hypothesis eleven was not supported.

Hypotheses 4 and 11 was further explored during the focus groups and interviews. Findings from the focus groups and interviews indicated that all participants showed a preference for the technological intervention. This was indicated through the positive comments mentioned in relation to the technological intervention compared to the text-based intervention comments. Taking into account both experimental studies combined with findings from the focus groups and interviews an overall trend can be observed suggestive of a preference for the technological intervention.

Among all participants more positive comments were made relating to the technological intervention than the text-based intervention. Shatil, Metzer, Horvitz and Miller (2010) suggested that personalized adaptive feedback is an important aspect with regard to promoting adherence to a cognitive training program. Shatil et al (2010) suggested that features used to achieve adaptive feedback include using a baseline cognitive evaluation to individualize the training regime, continually adapting difficulty level to the participant using an interactive adaptive system and lastly providing graphic and verbal feedback after each training task. The text-based intervention utilizes a baseline cognitive evaluation, but does not adapt difficulty level to the participant or offer verbal/graphic feedback. This could indicate why older adults preferred to use the technological intervention. The technological intervention follows all three features suggested by Shatil et al (2010) more closely to achieve adherence to the *Brain Training* regime and possibly more entertainment value. It is possible

to see the game as a more interesting and dynamic tool compared with the book achieving more adaptive feedback. Far less quotes relating to enjoyment were mentioned about the text-based intervention. The book is more static with less variety in the types of training tasks to complete. The text-based intervention consists of four tasks to complete, in comparison the technological intervention consists of 14 tasks.

The Survey of Older People and ICTs in Ireland 2008 (Work Research Centre & Age Action Ireland, 2009) indicated a preference among older people not to use ICTs. The findings from this study suggest that with regard to *Brain Training* the technological intervention is preferred by those aged over 65 years as opposed to the text-based intervention. This presents an interesting contrast to the findings of the Survey of Older People and ICTs in Ireland 2008 (Work Research Centre & Age Action Ireland, 2009).

5.6 Strengths and Limitations of the Study

There were a number of strengths and limitations which should be considered when interpreting the findings. Each study within Chapters Two, Three and Four had their own specific limitations which were previously discussed within these chapters.

One of the key strengths of this study is that it addresses the current lack of mixed-method studies evident in the literature, especially in an Irish context. There is a growing body of cognitive training research aimed at older adults. In comparison the literature available pertaining to young adults (third level student age) using specific *Brain Training* tools is quite limited.

Issues arising during the data collection stages of both the older adult and student studies were investigated in Chapter Four. The rich qualitative data obtained in the focus groups and interviews described in Chapter Four provided a platform to investigate a number of issues arising throughout the entire study. The data allowed for a better understanding of the opinions and attitudes of older adults and third level students to *Brain Training* tools and an opportunity to explore the positive and negative aspects of the interventions. Limitations of the study include the lack of cognitive or physical health information regarding participants and the rate of attrition.

With regard to the third level student study the lack of a non-intervention group may have limited the reliability of the results. The changes observed in some of the tests may have been due to practise effects. However as has been previously stated the study was primarily

concerned with the difference in scores between the intervention groups. The student population was not sufficiently large enough to allow for a comparator group or to employ a Solomon four group design.

5.6.1 Lack of Cognitive or Physical Health Information

Older adult participants were not asked about physical or cognitive health issues. The decision was made not to ask participants about these details for privacy reasons. This led to a situation where in a small number of instances participants revealed to the researcher that they suffered from a specific health problem, if the participant indicated a willingness to continue participation the researcher allowed this. It is hard to quantify how these cases affected the study as in most cases the participants finished the research. Eliminating a participant from the study for health reasons could have skewed the demographics of the population.

5.6.2 Rate of Attrition

The attrition rate for the study was 42.85% indicating a large percentage of the participants commenced the experiment but did not finish. This high drop-out rate could have been indicative of a lack of motivation to use or disinterest in the specific intervention. In order to investigate the reasons for older participants dropping out of the study a focus group was held with older adults. Interviews were also held with older adults from the completer group to investigate why they did not drop-out from the study. Focus group findings indicated that busy life schedules and family commitments were the main factors leading to discontinuing use of either intervention. However this focus group was conducted with four participants, two that had used the technology intervention and two participants that had used the text-based intervention. Due to the small numbers of participants attending the focus group it is difficult to say these were the only factors that led participants to discontinue using the interventions.

Larger group sizes and more equal group sizes could have lead to more generalizable results. In the older adult study the non-pretested groups in particular were half the size or less of the pre-tested groups. A limitation that future research could address was the lack of

an active comparator group. Lack of a random sampling method may have impacted on this study. However as this study was concerned primarily with voluntary participation in cognitive training the sampling method was deemed appropriate.

5.7 Implications of the Research

This research has provided evidence to support claims that regular use of cognitive skills training tools (text-based or technology based) can improve cognitive functioning as measured by intelligence and numerical ability tests in older adults. The findings support the use of Brain Training to improve numerical ability and to partially improve memory in third level students. Improvements were observed in healthy participants beyond tasks that were specifically targeted by the *Brain Training* tools. Unique to this study performance improvements were noticed among both older adults and third level student participants using text-based and technology tools. However as student participants did not improve on measures of intelligence the advantages of *Brain Training* for younger users to improve intelligence can be questioned.

This study provides support for the use of *Brain Training* devices among older adults. The cognitive health implications for older people of *Brain Training* are interesting and worthy further study. With current population trends pointing to an increase in the older population, in the future, tools that improve cognitive functioning could be warranted more than ever. Ways of improving cognitive health and staving off the declines associated with old age can help to improve quality of life, and perhaps have financial and independent living ramifications. The current research indicates that cognitive training presented through technological means is preferable to text-based cognitive training. More importantly cognitive training design should incorporate personalized adaptive feedback, use a baseline cognitive evaluation to individualize the training regime, continually adapt difficulty level to the participant using an interactive adaptive system and provide graphic and verbal feedback after each training task.

A number of positive and negative aspects of the *Brain Training* tools were explored during the focus groups and interviews conducted with participants. Positive comments relating to the technological intervention mentioned the fun aspects of the game, it is easy to follow and the incentivised system of game play was applauded. In contrast very few positive remarks were made relating to the text-based intervention. The negative aspects mentioned

included a number of problems found using both interventions. Identification of these problems could be useful to future developers of *Brain Training* tools. This research provides a critical appraisal of the *Brain Training* tools that could be used by future developers in order to develop *Brain Training* tools that suit the needs of the user better. This research can help point the way to future improvements in *Brain Training* tools.

5.8 Suggestions for Further Research

Much research in the field of cognitive training has utilized longitudinal methods studying older adults with particular diseases or health problems. Comparatively little research has been conducted with healthy adult participants using cognitive training tools such as *Brain Training* over shorter periods of time. This researcher suggests that more research be conducted to investigate the effects of *Brain Training* with young adults and healthy older adults. *Brain Training* is a growing business with a number of applications for use on the internet, on hand held devices, on telephones and in text. This study found little difference on measures of numerical ability and intelligence between using either a text-based or hand held technological device. However there is support for the use of the *Brain Training* game to improve verbal intelligence to a greater degree than the *Brain Training* book among older adults.

As *Brain Training* applications are designed for an increasing number of platforms, future studies could investigate the use of *Brain Training* tools across more devices such as internet based *Brain Training* tool and smart phone applications. The current research could benefit from a follow up study to investigate if the benefits gained among participants can last into the future. Future studies should investigate the use of *Brain Training* tools with older adults suffering from dementia, Alzheimer's disease or patients with neurological disorders. Further research could investigate the use of *Brain Training* tools with healthy older adults compared with older adults suffering from cognitive decline or dementia in an Irish context. Future studies could investigate a *Brain Training* program compared with an active comparator group utilizing a program designed similar to *Brain Training*, but involving tasks that do not engage high-level cognitive functioning. Using an active comparator group could help to control for the effects of using a new or novel intervention.

5.9 Conclusion

Forty older adults and twenty-seven third level students completed the research using one of two cognitive skills training interventions. The technological intervention consisted of the temporary provision of a Nintendo DS Lite Games Console and a copy of the game *Dr. Kawashima's Brain Training: How Old is Your Brain?* The text-based intervention consisted of a similar book Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Both interventions endeavor to improve cognitive functioning and were developed by the same neuroscientist.

A Solomon four group design was employed to determine which intervention demonstrated the greatest improvement among older adults. A separate between groups study was conducted with third level students who also received the cognitive skills training. Participants were asked to use either tool for 5-10 minutes per day. Pre and post-tests consisted of a measure of numerical ability, memory (MAC-S) and intelligence (WASI or Raven's SPM). Following training older adults indicated significant improvements on numerical ability and verbal intelligence on both interventions. Students indicated a significant improvement on numerical ability and a partial improvement on memory on both interventions following training. This finding suggests that both text and technology tools work equally well to improve numerical ability in both groups of participants, verbal intelligence among older adults and partially improve memory in student participants.

Among older adult participants using the technology based intervention a significant difference in change in verbal intelligence compared to the text-based intervention was observed. This indicates that the game *Dr. Kawashima's Brain Training: How Old is Your Brain?* can produce a more significant improvement in verbal intelligence than the book Kawashima's (2007) "*Train Your Brain: 60 Days to a Better Brain*". Findings from the older adult study indicated that participants using the technological intervention scored significantly higher on satisfaction scores than participants using the text-based intervention.

Focus groups and interviews were completed to investigate the high drop-out rate among older adults and attitudes of participants in each group towards the *Brain Training* tools. Findings indicated that the high dropout rate was not related to problems using the interventions but a busy life schedule and family commitments. A preference for the technological intervention was noted among participants in each group and a number of positive and negative aspects of each training tool were commented on.

This study adds to the under-represented research regarding healthy older adults and third level student participants using text and technology *Brain Training* tools in an Irish setting. With the well documented rise in the population and proportional rise in older adults, staying cognitively healthy will be an ever more important health issue in the future. The findings of this study are encouraging for older adults. There were two main findings from the study overall. Firstly, older adults can derive benefit in areas of numerical ability and intelligence through use of text and technology *Brain Training* tools. Secondly, student participants can derive improvements in numerical ability and a partial improvement in self reported memory. There was no significant difference found on measures of numerical ability, memory and intelligence between using the text or technology *Brain Training* tools in the student population. Among older adults a significantly greater improvement was noticed on verbal intelligence using the technological *Brain Training* tool compared with the text-based *Brain Training* tool. No other significant differences were observed between the text and technological interventions. Despite this, participants demonstrated a preference for the technological intervention.

Overall this research lends support for the use of *Brain Training* tools with older adults to improve numerical ability and intelligence. However among third level student age participants the research supports the use of *Brain Training* tools to improve numerical ability and partially improve memory. This research provides a critical appraisal of the *Brain Training* tools. The current research highlights both the positive and negative aspects of the text and technology interventions and adds to the academic research concerning *Brain Training* a field that is growing in popularity yet relatively light on academic research.

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Appendices

Appendix A: Screening Questionnaire

Screening Questionnaire

Please complete all sections of this using a black pen.
Do not leave sections blank.

Please circle

Gender: Male Female

Age: 65-70 71-75 76-80 81-85 85+

Level of Education: Primary level Secondary level Third level

Prior employment: _____

Please circle your level of confidence in your ability to complete each task along a scale of 1 – 5.

Examples of typical responses at each level are given below.

1 I am not aware of this.

2 I am aware of this but not experienced in using/implementing it.

3 I have used/done this occasionally but need further practice/training to be confident.

4 I am a regular and confident user of this.

5 I am fully competent with this and could confidently explain it to others.

Activities					
• Do Crossword or Word Search	1	2	3	4	5
• Do Sudoku	1	2	3	4	5
• Play Card Games e.g. Bridge	1	2	3	4	5
• Read Books which actively challenge the brain for example	1	2	3	4	5
• Used Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain")	1	2	3	4	5
Nintendo DS Lite Console					
• Have used the console	1	2	3	4	5
• Played Dr Kawashima's *Brain Training*	1	2	3	4	5
• Played other *Brain Training* games e.g. BrainAge	1	2	3	4	5
Using the Internet					
• Access an Internet site via its website address	1	2	3	4	5
• Use search engines to find information	1	2	3	4	5
• Use bookmarks / favourites for marking sites	1	2	3	4	5
• Download files from the internet	1	2	3	4	5
E-mail					
• Send and receive e-mail messages	1	2	3	4	5
• Attach files to outgoing e-mails	1	2	3	4	5
• Open and save files attached to incoming e-mails	1	2	3	4	5
• Create new contacts in address book	1	2	3	4	5
Word Processing					
• Use simple editing e.g. bold, italics, centering, font size etc	1	2	3	4	5
• Use a spellchecker	1	2	3	4	5
• Import text and images into a word processed document	1	2	3	4	5
• Include tables in a document	1	2	3	4	5
• Lay out text and images	1	2	3	4	5
• Prepare a simple document	1	2	3	4	5
Computer Management					
• Locate and run a programme (software application)	1	2	3	4	5
• Organise your electronic files into folders	1	2	3	4	5
• Search for files on the computer system	1	2	3	4	5
• Move files between drives (e.g. from A: to I)	1	2	3	4	5
• Prepare a simple document	1	2	3	4	5

Appendix B: Consent Form

Consent Form

Dear participant,

My name is Kevin Power and I am a postgraduate student in Dun Laoghaire Institute of Art Design and Technology (IADT). I am researching Cognitive Skills Improvements using technological and text-based skills training tools. Participants consenting to take part in the study will be given a screening test to evaluate the eligibility for the study. Eligible participants could be asked to take the following tests:

- A numeracy test rating skill levels in arithmetic lasting ten minutes.
- The MAC-S measuring memory abilities and the WASI measuring intelligence. Both tests lasting approximately half an hour each.

Participants will then be asked to use either Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain") or Dr Kawashima's *Brain Training* on the Nintendo DS Console 10 minutes every day for a two month period. After the two month period the numeracy test, MAC-S and the WASI will again be administered.

All data obtained will be treated with full anonymity and confidentiality and no individual participant will be identifiable if published. You are free to decline to answer any question, and are free to withdraw from the study at any time and all corresponding data will be destroyed. The welfare of participants is of the utmost importance to me and my supervisors.

I would be most grateful if you would consider taking part in this study. If you have any questions regarding this study, please do not hesitate to contact me. My email address is kevin.power@iadt.ie. Alternatively, if you wish to contact my supervisors, you can contact Dr Grainne Kirwan at grainne.kirwan@iadt.ie or Dr. Marion Palmer at marion.palmer@iadt.ie .

.....

I have read the above information and agree to participate in this research. I understand that I am free to withdraw from the study at any time and that I will not be identifiable in the study from its findings.

☐ My voice may be recorded during testing.

Signed _____ Print Name _____ Date _____

How would you prefer to be contacted by Phone, Email or Letter?

Phone no: _____

Email Address: _____

Contact Address: _____

_____

_____

Appendix C: Numerical Ability Trial

Numerical Ability Trial

3 x 6	=		2 + 6	=		10 - 9	=	
1 + 9	=		18 - 9	=		7 + 7	=	
10 – 3	=		6 x 3	=		3 x 1	=	
9 x 7	=		7 + 3	=		13 - 6	=	
2 – 2	=		1 x 8	=		7 x 9	=	
5 + 7	=		14 - 7	=		6 +10	=	
12 - 5	=		2 x 8	=		7 - 5	=	
2 + 9	=		4 x 2	=		4 + 2	=	
4 x 3	=		7 x 6	=		9 – 8	=	
5 - 2	=		4 + 4	=		9 x 4	=	
8 x 9	=		7 + 3	=		3 + 6	=	
7 - 5	=		4 x 7	=		17 – 9	=	
8 + 7	=		13 – 4	=		5 – 4	=	
1 + 6	=		7 + 8	=		6 x 8	=	
13 - 9	=		8 - 3	=		9 + 3	=	
3 x 6	=		9 - 5	=		17 - 6	=	
5 x 4	=		5 x 5	=				

Time Required: _____

Appendix D: Self Report Memory Scale (MAC-S)

MAC S (Self Report Memory Scale)

Part A

	very poor	*poor*	*ok*	*good*	*very good*
In general, as compared to the average individual, how would you describe your memory?	1	2	3	4	5
	much worse	*worse*	*the same*	*better*	*much better*
How would you describe your memory, on the whole, as compared to when you were younger?	1	2	3	4	5
	much slower	*slower*	*the same*	*faster*	*much faster*
Compared to when you were younger, how would you describe the speed with which you now remember things?	1	2	3	4	5
	serious concern	*moderate concern*	*some*	*little concern*	*no concern*
How much concern or distress do you feel about your memory at this time?	1	2	3	4	5

Part B
How would you rate your ability to remember?

	Very poor	*poor*	*ok*	*good*	*Very good*
Gifts you have received at special occasions during the past several years	1	2	3	4	5
Details of holidays or special occasions of your childhood	1	2	3	4	5
Details of family events that occurred during the past year	1	2	3	4	5
Who was with you at events attended weeks or months ago	1	2	3	4	5
The name of a person just introduced to you	1	2	3	4	5
Telephone numbers that you use on a daily or weekly basis	1	2	3	4	5
Addresses of close family members, friends, or associates	1	2	3	4	5
Telephone numbers that you use on a monthly basis or less often	1	2	3	4	5
To turn out lights, turn off appliances, and lock doors when leaving home	1	2	3	4	5
To write letters you intend to write or make telephone calls you intend to make	1	2	3	4	5
To take along, when leaving the home or office, any items that you intended to take (for instance, an umbrella or a letter to mail)	1	2	3	4	5
Where you have put objects (such as keys) in the home or office	1	2	3	4	5

Part B
How would you rate your ability to remember?

	Very poor	*poor*	*ok*	*good*	*Very good*
Specific facts from a newspaper or magazine article you have just finished reading	1	2	3	4	5
Meanings of words that you use only rarely	1	2	3	4	5
Meanings of words you once knew very well	1	2	3	4	5
Verbal directions to a geographic location given minutes earlier	1	2	3	4	5
Which door you entered when shopping in a large department store or mall	1	2	3	4	5
How to reach a location you have visited once or twice	1	2	3	4	5

Part C
How often would you?

	never	*very rarely*	*sometimes*	*quite often*	*very often*
Have difficulty recalling a word you wish to use	1	2	3	4	5
Feel that a word or name you want to remember is 'on the tip of your tongue' but cannot be recalled	1	2	3	4	5
Forget the name of a familiar object	1	2	3	4	5
Fail to remember a name or word when trying, but recall it later	1	2	3	4	5
Take a surprisingly long time to recall a fact that you know quite well (and do eventually remember)	1	2	3	4	5
Miss the point someone else is making during a conversation	1	2	3	4	5
Have difficulty following a conversation when there are distractions in the environment such as noise from a TV or a radio	1	2	3	4	5
Have to re-read earlier paragraphs from a newspaper or magazine story to understand the point	1	2	3	4	5
Have trouble finding your place again when interrupted in reading	1	2	3	4	5
Confuse one word with another when they sound the same	1	2	3	4	5

Part C ***How often would you?***	*never*	*very rarely*	*sometimes*	*quite often*	*very often*
Go into a room to get something and forget what you are after	1	2	3	4	5
Forget to bring up an important point you had intended to mention during a conversation	1	2	3	4	5
Arrive at the grocery store or pharmacy and forget what you intended to buy	1	2	3	4	5
Store an important item in a place where it will be safe and then forget where it is	1	2	3	4	5
Have to stop and think when distinguishing right from left	1	2	3	4	5
Dial a number and forget whom you were calling before the phone is answered	1	2	3	4	5
Forget an appointment or other event that is very important to you	1	2	3	4	5
Forget which waiter took your order in a restaurant	1	2	3	4	5
Fail to recognize people who recognize you	1	2	3	4	5
Meet people who seem familiar but can't remember where you met them	1	2	3	4	5

Appendix E: Book Satisfaction Questionnaire

Participant Satisfaction Questionnaire

The following questions are about how you felt about the study.

The following statements are some things participants might say about using Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain". Please read each one carefully. It is important to the study that both your good and bad feelings are given about using the console.

How strongly do you AGREE or DISAGREE with each of the following statements?

(Circle one number on each line)

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. I enjoyed using Train Your Brain.....	1	2	3	4	5
2. I found Train Your Brain easy to use.....	1	2	3	4	5
3. I used the Train Your Brain every day.....	1	2	3	4	5
4. I feel confident using Train Your Brain.....	1	2	3	4	5
5. I would consider buying Train Your Brain to use everyday.....	1	2	3	4	5
6. I would recommend Train Your Brain to a friend.....	1	2	3	4	5
7. I would like to use more books that train the brain.....	1	2	3	4	5
8. I feel I have benefited positively from taking part in the study.....	1	2	3	4	5
9. Questions I had regarding the *Brain Training* were answered well by the researcher.....	1	2	3	4	5

Appendix F: Game Satisfaction Questionnaire

Participant Satisfaction Questionnaire

The following questions are about how you felt about the study.

The following statements are some things participants might say about using Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain". Please read each one carefully. It is important to the study that both your good and bad feelings are given about using the console.

How strongly do you AGREE or DISAGREE with each of the following statements?

(Circle one number on each line)

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. I enjoyed using *Brain Training*.....	1	2	3	4	5
2. I found *Brain Training* easy to use.....	1	2	3	4	5
3. I used the *Brain Training* every day.....	1	2	3	4	5
4. I feel confident using *Brain Training*.....	1	2	3	4	5
5. I would consider buying *Brain Training* to use everyday.....	1	2	3	4	5
6. I would recommend *Brain Training* to a friend.....	1	2	3	4	5
7. I would like to use more games that train the brain.....	1	2	3	4	5
8. I feel I have benefited positively from taking part in the study.....	1	2	3	4	5
9. Questions I had regarding the *Brain Training* were answered well by the researcher.....	1	2	3	4	5

Appendix G: Participant Debrief

Participant Debrief

Title of Study: Evaluation of Cognitive Skills Improvements using technological and text-based skills training tools

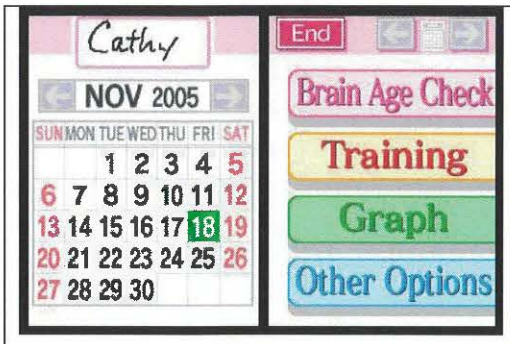
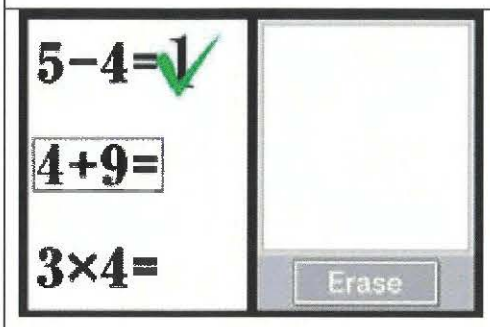
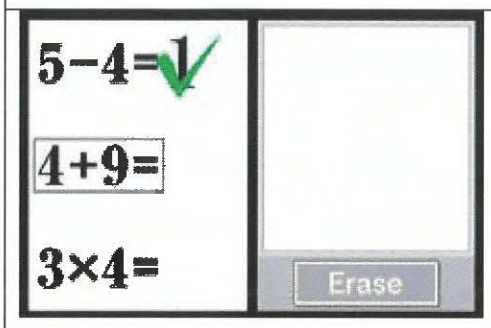
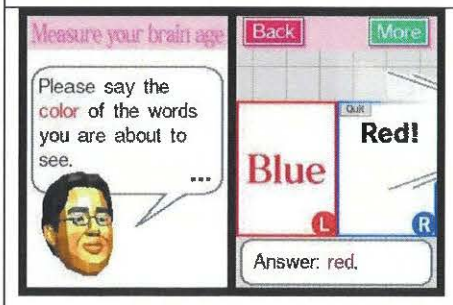
Thank you for taking part in this study. The aims of this study are to assess the effectiveness of skills training tools, and to determine if technological or text-based tools are more effective.

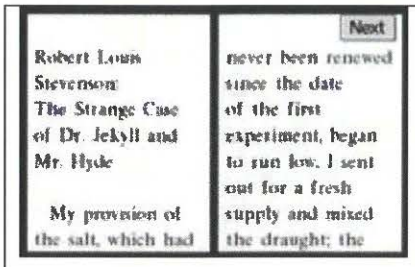
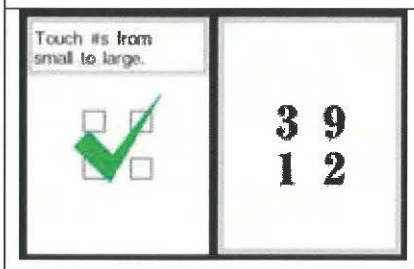
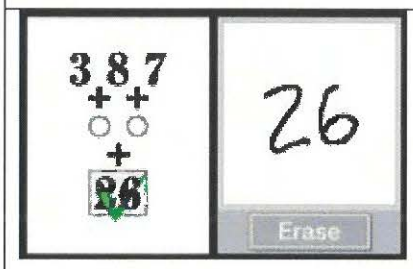
If you would like any information about the results of the study once it is completed, or if you have any questions or queries about the study, please feel free to contact me. Tel. 086 1955497 or email: kevin.power@iadt.ie.

Alternatively, if you wish to contact my supervisors, you can contact Dr Grainne Kirwan at grainne.kirwan@iadt.ie or Ms. Marion Palmer at marion.palmer@iadt.ie .

If the study has affected you in any way, please contact The Senior Helpline on 1850 440 444, or visit www.ageaction.ie for information regarding Support groups for the elderly. If the study raises any questions concerning Alzheimer's or Dementia please contact The Alzheimer's Society of Ireland National Helpline on 1800 341 341 or visit www.alzheimer.ie.

Appendix H: Dr. Kawashima's *Brain Training*: How Old is Your Brain? Screenshots

 Figure 1.1: Calander/stamp screen	Here the user can choose training, brain age check, graph and other options. Brain Age check will check your brain age. Training takes you to the training programs. Graph displays your daily results displayed over time. Other options allow you to change various settings. For every date the participants uses the training a stamp is given.
Training Programs	
 Figure 2.1: Calculations x20	The user solves problems that appear on the display screen and writes the answers on the Touch Screen as quickly as possible. The user is asked to write your numbers with large, clear strokes. A final time is recorded, and wrong answers cost a five second time penalty.
 Figure 2.2: Calculations x100	This program is the same as Calculationsx20 with 80more
 Figure 2.3: Stroop Test	During the Stroop test, coloured words appear on screen. The user must say the colour of the word that appears into the microphone–not the word itself.

 Figure 2.4: Reading Aloud	The user is offered a passage to read aloud as quickly as possible. The time taken to read the entire passage will be recorded
 Figure 2.5: Low to High	Numbers appear momentarily on the screen. Boxes will then appear where the numbers used to be. Tap these boxes in the order of numbers they contained, moving from lowest to highest
 Figure 2.6: Syllable Count	During this training program the user must read the passage on the screen, then write the total number of syllables it contains on the Touch Screen.
 Figure 2.7: Triangle Math	Once you finish the top level, solve the problems in the second row using the answers derived from above. Continue this process until only one answer remains. This number is written in the frame provided on the Touch Screen.

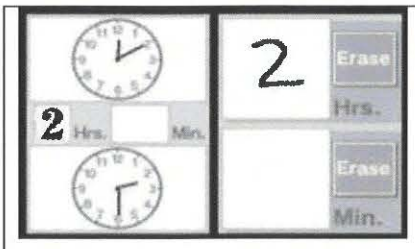
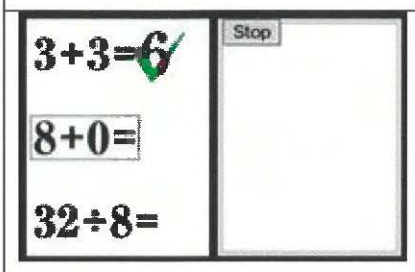
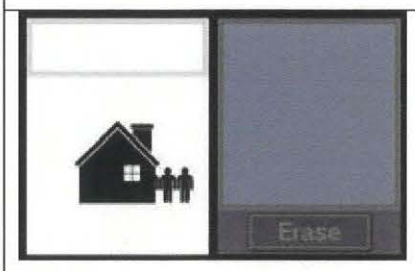
 Figure 2.8: Time Lapse	The user is asked to determine the amount of time that has passed between the clock on the top and the clock on the bottom
 Figure 2.9: Voice Calculations	Problems are solved and answers are spoken into the microphone.
 Figure 2.10: Head Count	Track the people as they enter and leave the house. Write the number of people left inside the house at the end on the Touch Screen.

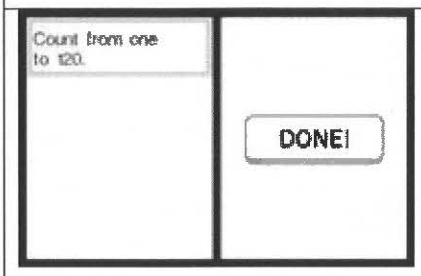
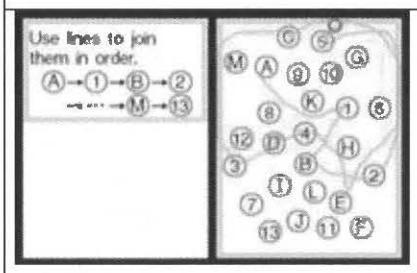
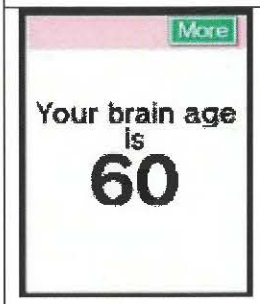
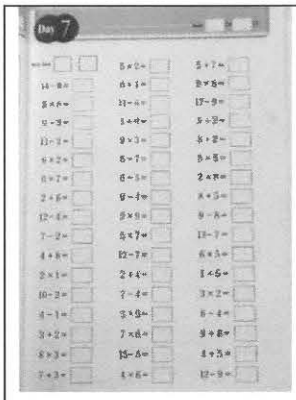
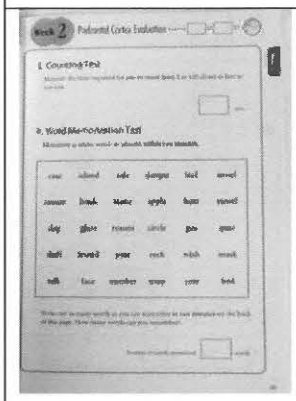
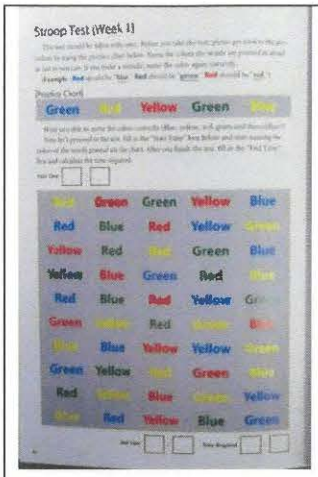
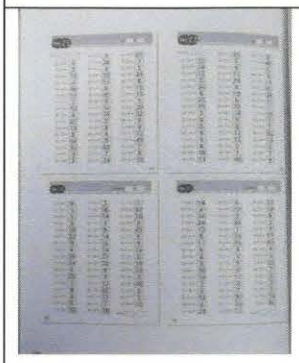
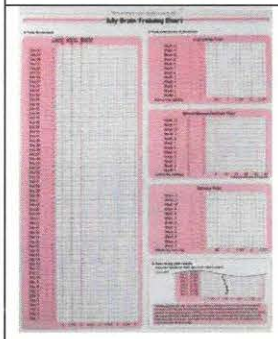
 Figure 2.11: Word Memorizarion	Memorize as many of the displayed words as possible within a two minute time period. Then on the touch screen as many memorized words a written as possible in three minutes.
 Figure 2.12: Speed Counting	Count out loud from 1 to 120 as quickly as possible. Pronouncing every number correctly. When user is finished counting, tap "DONE!"
 Figure 2.13: Connect Maze	Drag the stylus as quickly as possible (and without lifting it) from item to item in the order of A to 1 to B to 2 to C to 3, etc. The user cannot touch any letter or number but the one that you are aiming for.

 Figure 2.14: Number Cruncher	Numbers of various types are scattered across the display screen. Read the question carefully and write the corresponding answer on the Touch Screen.
 Figure 3.1: Brain Age	When the three tests are completed brain age of the user appears.
 Figure 3.2: Graphs	Results can be displayed for different training programs using graphs.

Appendix I: Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain"

 **Figure 4.1 Daily Worksheet**	Users are asked to solve the calculations on the front and back of one worksheet each day, time themselves and record the time required. The user can check their answers with the correct answers at the back of the book. If the user has entered an incorrect figure the user is expected to add 5 seconds onto the overall time required for each mistake.
 **Figure 4.2 Prefrontal Cortex Evaluation**	After every five days the user must take a prefrontal cortex evaluation. Consisting of a counting test, word memorization test and Stroop test. **1.Counting test:** the user must measure the time required to count form 1 to 120 aloud as fast as possible. **2.Word memorization test:** the user is asked to memorize as many words from a list of 30 words as possible in two minutes. After the two minutes the user turns the page and writes down as many words as they can remember. The number of correct answers is noted as the score.
 **Figure 4.3 Prefrontal Cortex Evaluation**	**Word Memorizarion** test answers: the user notes answers to the word memorization test.

 **Figure 4.4 Stroop test**	**3. Stroop Test:** The user must turn to the appendix at the back of the book. The Stroop test is a chart of colour names. Often the colour names are printed in a different colour to the colour they are actually labelled. The user is required to say the colour of each word that is printed aloud. The time required to name all the colours is measured.
 **Figure 4.5 Calculation answers**	Answers are given for each daily training worksheet.
 **Figure 4.6 *Brain Training* Chart**	The *Brain Training* chart The user can plot progress in the daily worksheets, counting test, word memorization test and Stroop test with the graphs provided at the end of the book.

Appendix J: Power, Kirwan & Palmer (2010)

Power , K., Kirwan, G., & Palmer, M. (2010). Use of the Wechsler Memory Scale-Third Edition Abbreviated (WMS-III Abbreviated) with older adults. *Irish Psychologist Magazine, 36(8)*, 202 -203.

Use of the Wechsler Memory Scale-Third Edition Abbreviated (WMS-III Abbreviated) with older adults

While it is generally considered that many established psychometric tests are appropriate for all adult age groups, it is possible that this may not be the case. Problems experienced administering the Wechsler Memory Scale-Third Edition Abbreviated (WMS-III Abbreviated) to older adults during pilot testing are presented in this article. The WMS-III Abbreviated is described and previous studies that have questioned the use of the previous version of the test are discussed. Finally an alternative memory test is provided for use in this study.

Criticisms of the Wechsler Memory Scale-Third Edition Abbreviated

According to Wechsler (2002) the WMS-III Abbreviated is a reliable survey of memory abilities. The WMS-III Abbreviated is used to measure working memory, auditory memory and visual memory in the absence of extended memory testing. The test is administered individually. According to the WMS-III Abbreviated Manual it can be administered in 15-20 minutes by trained examiners and is appropriate for use with participants aged 16-89 years.

The WMS-III Abbreviated was developed to produce an estimate of an participant's general memory functioning in the absence of an extended memory test. Clinical applications include diagnosis and identification of memory impairment, early identification of dementias and degenerative conditions, measurement of memory impairment and serial assessment of memory to record change in cognitive functioning. However according to Zarit and Zarit (2006) some of the tests involved in the WMS-III can be challenging or frustrating for people with low education or occupational attainment (Zarit & Zarit, 2006, p. 161).

Similarly Levy (2006) noted problems using the using the WMS-III faces subset to investigate visual memory impairment. The overall effect of testing older adults with multiple measures has been investigated by Brooks, Iverson, Holdnack and Feldman (2008). This study investigated the base rates of low memory scores on the WMS-III in 550 older adults aged 55 to 87 years. Findings from the study indicate that when multiple measures are administered healthy older adults can obtain low scores indicating mild cognitive impairment. Brooks et al (2008) suggests that misinterpretation of the results has led to the misclassification of mild cognitive impairment in healthy older adults. These findings are attributed to the use of the WMS-III however three of the co-normed episodic memory tests are given in the WMS-III abbreviated.

Current Observations

As part of a masters by research the cognitive effects of aging in older adults is being investigated. Specifically the study attempts to investigate how the use of cognitive skills training tools can improve cognitive functioning in adults over the age of 65. Two pilot

studies have been completed with interesting findings regarding the use of the WMS-III Abbreviated. The pilots were carried out using male and female participants. The male participant was aged 82 years and the female participant was aged 73 years. In both cases the participants were asked to complete a simple numerical ability test after which the WMS-III Abbreviated and the the Wechsler Abbreviated Scale of Intelligence (WASI) were administered. In both cases administering the WMS-III Abbreviated presented problems.

During testing the older male participant showed signs of fatigue and distress. When asked, the participant responded that the WMS-III Abbreviated was "very tiring". The participant appeared in distress and asked to withdraw from study. In the second pilot the younger female participant completed the WMS-III Abbreviated. However the time taken to finish was approximately one hour; three times longer than the time specified by the WMS-III Abbreviated Manual. The participant commented that the WMS-III Abbreviated was difficult and tiring. Preliminary findings from the pilot studies agree with Zarit & Zarit (2006) that tasks from the WMS can be frustrating for older adults.

The pilot studies yielded important information regarding the use of the WMS-III Abbreviated with elderly participants. Three key flaws observed were that it was tiring, it was overly long and it caused distress. As three pre-tests are being administered during the testing period it is desirable that the measures used are short and do not exhaust the participants. In the interest of the participants well being and ethics it is imperative that no participant be caused distress. Due to these findings the WMS-III Abbreviated was deemed inadequate for use with adults aged over 65 years in this study.

A suitable alternative memory scale for the purposes of this study was sought. The Memory Assessment Clinics Self-Rating Scale (MAC-S; Winterling, Crook, Salama, & Gobert, 1986) seems to be a good alternative. The MAC-S includes 21 ability-to-remember items, 24 items assessing frequency of occurrence of memory failures, and 4 global rating items. The five ability factors include Remote Personal Memory, Numeric Recall, Everyday Task-Oriented Memory, Word Recall/Semantic Memory (with a secondary representation of Reading Recall), and Spatial and Topographic Memory. The five Frequency of Occurrence factors comprise Word and Fact Recall or Semantic Memory, Attention/Concentration, Everyday Task-Oriented Memory, General Forgetfulness, and Facial Recognition. These items are scored on a 5 point Likert scale. According to Crook and Larrabee (1990) the advantages of the MAC-S include the brevity of the scale, the wide range of memory self-report factors, and a large normative base that covers the adult age range of 18 to 92 years. The factor structure is deemed extremely stable, which is minimally affected by age or sex, further enhances the research and clinical applications of this scale.

Conclusions

The validity of using a self report measure as an alternative to the WMS-III Abbreviated can be called into question. However due to the above mentioned faults when testing with older adults' participant wellbeing must be paramount.

The point must be made that this pilot study was carried out with two participants. The findings cannot be generalised to other studies. However the findings from this pilot study suggest that the use of the WMS-III Abbreviated with adults aged over 65 may not be practical in all cases. Findings from the initial pilot studies would suggest that distress could be caused to a large amount of participants if the scale was used in the wider study. Furthermore it is desirable that the testing period be kept to a minimum. Using a memory scale that lasts an hour is not satisfactory.

References

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Appendix K: Table of Elderly group Meetings

Meeting		**Date**	**Numbers attended Approx**
Exercise with the Elderly Tallaght		20/04/2009	20
St Aengus Active Retirement		12/05/2009	30
Walkinstown Active Retirement		04/06/2009	40
Knocklyon Active Retirement		9/07/2019	15
Ballyroan U3A		14/09/2009	50
Sutton/Baldoyle U3A		15/09/2009	15
Blackrock U3A		18/09/2009	20
Dublin City U3A		27/10/2009	70
Ballymun U3A		02/11/2009	30
Knocklyon Active Retirement		23/03/2010	15
Templeogue Active Retirement		26/04/2010	100
Dun Laoghaire Active Retirement		30/04/2010	40
Foxrock Active Retirement		27/05/2010	100
Total	**13meetings**		**545**

Appendix L: Older adult Study SPSS Data Output

One way between subjects ANOVA

NAT

Tests of Between-Subjects Effects

Dependent Variable:Numerical Ability Trial Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1228.310[a]	3	409.437	.294	.829	.024
Intercept	271262.516	1	271262.516	194.936	.000	.844
Condition	1228.310	3	409.437	.294	.829	.024
Error	50095.590	36	1391.544			
Total	431964.000	40				
Corrected Total	51323.900	39				

a. R Squared = .024 (Adjusted R Squared = -.057)

MAC-S Overall

Tests of Between-Subjects Effects

Dependent Variable:Total MAC-S Score post test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	103.038[a]	3	34.346	.341	.795	.028
Intercept	469498.732	1	469498.732	4667.292	.000	.992
Condition	103.038	3	34.346	.341	.795	.028
Error	3621.362	36	100.593			
Total	631728.000	40				
Corrected Total	3724.400	39				

a. R Squared = .028 (Adjusted R Squared = -.053)

MAC-S Part A

Tests of Between-Subjects Effects

Dependent Variable:part a global items overall score MAC-S postest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	23.345[a]	3	7.782	1.249	.306	.094
Intercept	4065.313	1	4065.313	652.612	.000	.948
Condition	23.345	3	7.782	1.249	.306	.094
Error	224.255	36	6.229			
Total	5446.000	40				
Corrected Total	247.600	39				

a. R Squared = .094 (Adjusted R Squared = .019)

MAC-S Part B

Tests of Between-Subjects Effects

Dependent Variable:part b ability to remember items overall score MAC-S posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	113.420[a]	3	37.807	.445	.722	.036
Intercept	121991.094	1	121991.094	1436.807	.000	.976
Condition	113.420	3	37.807	.445	.722	.036
Error	3056.555	36	84.904			
Total	169709.000	40				
Corrected Total	3169.975	39				

a. R Squared = .036 (Adjusted R Squared = -.045)

MAC-S Part C

Tests of Between-Subjects Effects

Dependent Variable:part c frequency of occurance items overall score MAC-S posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	17.285[a]	3	5.762	.045	.987	.004
Intercept	74075.277	1	74075.277	579.708	.000	.942
Condition	17.285	3	5.762	.045	.987	.004
Error	4600.090	36	127.780			
Total	102133.000	40				
Corrected Total	4617.375	39				

a. R Squared = .004 (Adjusted R Squared = -.079)

WASI Performance

Tests of Between-Subjects Effects

Dependent Variable:WASI Performance post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	47.982[a]	3	15.994	.067	.977	.006
Intercept	390782.233	1	390782.233	1636.024	.000	.978
Condition	47.982	3	15.994	.067	.977	.006
Error	8598.993	36	238.861			
Total	528715.000	40				
Corrected Total	8646.975	39				

a. R Squared = .006 (Adjusted R Squared = -.077)

WASI Verbal

Tests of Between-Subjects Effects

Dependent Variable:WASI Verbal post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1368.602[a]	3	456.201	3.733	.020	.237
Intercept	464305.426	1	464305.426	3799.469	.000	.991
Condition	1368.602	3	456.201	3.733	.020	.237
Error	4399.298	36	122.203			
Total	655508.000	40				
Corrected Total	5767.900	39				

a. R Squared = .237 (Adjusted R Squared = .174)

WASI Total

Tests of Between-Subjects Effects

Dependent Variable:WASI 4 subset score post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1494.281[a]	3	498.094	.951	.426	.073
Intercept	1706769.511	1	1706769.511	3258.296	.000	.989
Condition	1494.281	3	498.094	.951	.426	.073
Error	18857.619	36	523.823			
Total	2352276.000	40				
Corrected Total	20351.900	39				

a. R Squared = .073 (Adjusted R Squared = -.004)

Planned comparisons

WASI Verbal

Contrast Coefficients

Contrast	Condition			
	ds	book	Pds	Pbk
1	1	0	-1	0

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
WASI Verbal post-test	Assume equal variances	1	-19.2500	6.26733	-3.071	36	.004
	Does not assume equal variances	1	-19.2500	7.50136	-2.566	3.753	.066

Contrast Coefficients

Contrast	Condition			
	ds	book	Pds	Pbk
1	0	0	-1	1

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
WASI Verbal post-test	Assume equal variances	1	-.1667	4.10799	-.041	36	.968
	Does not assume equal variances	1	-.1667	3.68910	-.045	26.848	.964

Contrast Coefficients

Contrast	Condition			
	ds	book	Pds	Pbk

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
WASI Verbal post-test	Assume equal variances	1	-.1667	4.10799	-.041	36	.968

1	0	-1	0	1

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
WASI Verbal post-test	Assume equal variances	1	5.9048	5.06008	1.167	36	.251
	Does not assume equal variances	1	5.9048	5.82601	1.014	9.599	.336

Contrast Coefficients

Contrast	Condition			
	ds	book	Pds	Pbk
1	1	-1	0	0

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
WASI Verbal post-test	Assume equal variances	1	-13.1786	6.92880	-1.902	36	.065
	Does not assume equal variances	1	-13.1786	8.75233	-1.506	6.132	.182

Two by Two within-subjects ANOVA

Numerical Ability Test

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	2814.446	1	2814.446	.640	.438	.047
	Greenhouse-Geisser	2814.446	1.000	2814.446	.640	.438	.047
	Huynh-Feldt	2814.446	1.000	2814.446	.640	.438	.047
	Lower-bound	2814.446	1.000	2814.446	.640	.438	.047
Error(intervention)	Sphericity Assumed	57200.304	13	4400.023			
	Greenhouse-Geisser	57200.304	13.000	4400.023			
	Huynh-Feldt	57200.304	13.000	4400.023			
	Lower-bound	57200.304	13.000	4400.023			
cond	Sphericity Assumed	13423.018	1	13423.018	36.130	.000	.735
	Greenhouse-Geisser	13423.018	1.000	13423.018	36.130	.000	.735
	Huynh-Feldt	13423.018	1.000	13423.018	36.130	.000	.735
	Lower-bound	13423.018	1.000	13423.018	36.130	.000	.735
Error(cond)	Sphericity Assumed	4829.732	13	371.518			
	Greenhouse-Geisser	4829.732	13.000	371.518			
	Huynh-Feldt	4829.732	13.000	371.518			
	Lower-bound	4829.732	13.000	371.518			
intervention * cond	Sphericity Assumed	325.446	1	325.446	.537	.477	.040
	Greenhouse-Geisser	325.446	1.000	325.446	.537	.477	.040
	Huynh-Feldt	325.446	1.000	325.446	.537	.477	.040
	Lower-bound	325.446	1.000	325.446	.537	.477	.040
Error(intervention*cond)	Sphericity Assumed	7881.304	13	606.254			
	Greenhouse-Geisser	7881.304	13.000	606.254			
	Huynh-Feldt	7881.304	13.000	606.254			
	Lower-bound	7881.304	13.000	606.254			

MAC-S Total

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	11.161	1	11.161	.051	.825	.004
	Greenhouse-Geisser	11.161	1.000	11.161	.051	.825	.004
	Huynh-Feldt	11.161	1.000	11.161	.051	.825	.004
	Lower-bound	11.161	1.000	11.161	.051	.825	.004
Error(intervention)	Sphericity Assumed	2842.589	13	218.661			
	Greenhouse-Geisser	2842.589	13.000	218.661			
	Huynh-Feldt	2842.589	13.000	218.661			
	Lower-bound	2842.589	13.000	218.661			
cond	Sphericity Assumed	15.018	1	15.018	.287	.601	.022
	Greenhouse-Geisser	15.018	1.000	15.018	.287	.601	.022
	Huynh-Feldt	15.018	1.000	15.018	.287	.601	.022
	Lower-bound	15.018	1.000	15.018	.287	.601	.022
Error(cond)	Sphericity Assumed	679.732	13	52.287			
	Greenhouse-Geisser	679.732	13.000	52.287			
	Huynh-Feldt	679.732	13.000	52.287			
	Lower-bound	679.732	13.000	52.287			
intervention * cond	Sphericity Assumed	1.446	1	1.446	.018	.896	.001
	Greenhouse-Geisser	1.446	1.000	1.446	.018	.896	.001
	Huynh-Feldt	1.446	1.000	1.446	.018	.896	.001
	Lower-bound	1.446	1.000	1.446	.018	.896	.001
Error(intervention*cond)	Sphericity Assumed	1049.304	13	80.716			
	Greenhouse-Geisser	1049.304	13.000	80.716			
	Huynh-Feldt	1049.304	13.000	80.716			
	Lower-bound	1049.304	13.000	80.716			

MAC-S Part A

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	.071	1	.071	.014	.909	.001
	Greenhouse-Geisser	.071	1.000	.071	.014	.909	.001
	Huynh-Feldt	.071	1.000	.071	.014	.909	.001
	Lower-bound	.071	1.000	.071	.014	.909	.001
Error(intervention)	Sphericity Assumed	67.929	13	5.225			
	Greenhouse-Geisser	67.929	13.000	5.225			
	Huynh-Feldt	67.929	13.000	5.225			
	Lower-bound	67.929	13.000	5.225			
cond	Sphericity Assumed	.071	1	.071	.062	.807	.005
	Greenhouse-Geisser	.071	1.000	.071	.062	.807	.005
	Huynh-Feldt	.071	1.000	.071	.062	.807	.005
	Lower-bound	.071	1.000	.071	.062	.807	.005
Error(cond)	Sphericity Assumed	14.929	13	1.148			
	Greenhouse-Geisser	14.929	13.000	1.148			
	Huynh-Feldt	14.929	13.000	1.148			
	Lower-bound	14.929	13.000	1.148			
intervention * cond	Sphericity Assumed	1.143	1	1.143	.712	.414	.052
	Greenhouse-Geisser	1.143	1.000	1.143	.712	.414	.052
	Huynh-Feldt	1.143	1.000	1.143	.712	.414	.052
	Lower-bound	1.143	1.000	1.143	.712	.414	.052
Error(intervention*cond)	Sphericity Assumed	20.857	13	1.604			
	Greenhouse-Geisser	20.857	13.000	1.604			
	Huynh-Feldt	20.857	13.000	1.604			
	Lower-bound	20.857	13.000	1.604			

MAC-S Part B

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	30.018	1	30.018	.133	.722	.010
	Greenhouse-Geisser	30.018	1.000	30.018	.133	.722	.010
	Huynh-Feldt	30.018	1.000	30.018	.133	.722	.010
	Lower-bound	30.018	1.000	30.018	.133	.722	.010
Error(intervention)	Sphericity Assumed	2943.232	13	226.402			
	Greenhouse-Geisser	2943.232	13.000	226.402			
	Huynh-Feldt	2943.232	13.000	226.402			
	Lower-bound	2943.232	13.000	226.402			
cond	Sphericity Assumed	15.018	1	15.018	.465	.507	.035
	Greenhouse-Geisser	15.018	1.000	15.018	.465	.507	.035
	Huynh-Feldt	15.018	1.000	15.018	.465	.507	.035
	Lower-bound	15.018	1.000	15.018	.465	.507	.035
Error(cond)	Sphericity Assumed	420.232	13	32.326			
	Greenhouse-Geisser	420.232	13.000	32.326			
	Huynh-Feldt	420.232	13.000	32.326			
	Lower-bound	420.232	13.000	32.326			
intervention * cond	Sphericity Assumed	15.018	1	15.018	.381	.548	.028
	Greenhouse-Geisser	15.018	1.000	15.018	.381	.548	.028
	Huynh-Feldt	15.018	1.000	15.018	.381	.548	.028
	Lower-bound	15.018	1.000	15.018	.381	.548	.028
Error(intervention*cond)	Sphericity Assumed	512.232	13	39.402			
	Greenhouse-Geisser	512.232	13.000	39.402			
	Huynh-Feldt	512.232	13.000	39.402			
	Lower-bound	512.232	13.000	39.402			

MAC-S Part C

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	82.571	1	82.571	.314	.585	.024
	Greenhouse-Geisser	82.571	1.000	82.571	.314	.585	.024
	Huynh-Feldt	82.571	1.000	82.571	.314	.585	.024
	Lower-bound	82.571	1.000	82.571	.314	.585	.024
Error(intervention)	Sphericity Assumed	3421.929	13	263.225			
	Greenhouse-Geisser	3421.929	13.000	263.225			
	Huynh-Feldt	3421.929	13.000	263.225			
	Lower-bound	3421.929	13.000	263.225			
cond	Sphericity Assumed	.071	1	.071	.003	.956	.000
	Greenhouse-Geisser	.071	1.000	.071	.003	.956	.000
	Huynh-Feldt	.071	1.000	.071	.003	.956	.000
	Lower-bound	.071	1.000	.071	.003	.956	.000
Error(cond)	Sphericity Assumed	287.429	13	22.110			
	Greenhouse-Geisser	287.429	13.000	22.110			
	Huynh-Feldt	287.429	13.000	22.110			
	Lower-bound	287.429	13.000	22.110			
intervention * cond	Sphericity Assumed	37.786	1	37.786	.983	.340	.070
	Greenhouse-Geisser	37.786	1.000	37.786	.983	.340	.070
	Huynh-Feldt	37.786	1.000	37.786	.983	.340	.070
	Lower-bound	37.786	1.000	37.786	.983	.340	.070
Error(intervention*cond)	Sphericity Assumed	499.714	13	38.440			
	Greenhouse-Geisser	499.714	13.000	38.440			
	Huynh-Feldt	499.714	13.000	38.440			
	Lower-bound	499.714	13.000	38.440			

WASI Total

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intervention	Sphericity Assumed	138.286	1	138.286	.172	.685	.013
	Greenhouse-Geisser	138.286	1.000	138.286	.172	.685	.013
	Huynh-Feldt	138.286	1.000	138.286	.172	.685	.013
	Lower-bound	138.286	1.000	138.286	.172	.685	.013
Error(Intervention)	Sphericity Assumed	10434.214	13	802.632			
	Greenhouse-Geisser	10434.214	13.000	802.632			
	Huynh-Feldt	10434.214	13.000	802.632			
	Lower-bound	10434.214	13.000	802.632			
test	Sphericity Assumed	1716.071	1	1716.071	6.142	.028	.321
	Greenhouse-Geisser	1716.071	1.000	1716.071	6.142	.028	.321
	Huynh-Feldt	1716.071	1.000	1716.071	6.142	.028	.321
	Lower-bound	1716.071	1.000	1716.071	6.142	.028	.321
Error(test)	Sphericity Assumed	3632.429	13	279.418			
	Greenhouse-Geisser	3632.429	13.000	279.418			
	Huynh-Feldt	3632.429	13.000	279.418			
	Lower-bound	3632.429	13.000	279.418			
Intervention * test	Sphericity Assumed	5.786	1	5.786	.019	.892	.001
	Greenhouse-Geisser	5.786	1.000	5.786	.019	.892	.001
	Huynh-Feldt	5.786	1.000	5.786	.019	.892	.001
	Lower-bound	5.786	1.000	5.786	.019	.892	.001
Error(Intervention*test)	Sphericity Assumed	3930.714	13	302.363			
	Greenhouse-Geisser	3930.714	13.000	302.363			
	Huynh-Feldt	3930.714	13.000	302.363			
	Lower-bound	3930.714	13.000	302.363			

WASI Verbal

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	311.143	1	311.143	5.985	.029	.315
	Greenhouse-Geisser	311.143	1.000	311.143	5.985	.029	.315
	Huynh-Feldt	311.143	1.000	311.143	5.985	.029	.315
	Lower-bound	311.143	1.000	311.143	5.985	.029	.315
Error(intervention)	Sphericity Assumed	675.857	13	51.989			
	Greenhouse-Geisser	675.857	13.000	51.989			
	Huynh-Feldt	675.857	13.000	51.989			
	Lower-bound	675.857	13.000	51.989			
cond	Sphericity Assumed	171.500	1	171.500	6.307	.026	.327
	Greenhouse-Geisser	171.500	1.000	171.500	6.307	.026	.327
	Huynh-Feldt	171.500	1.000	171.500	6.307	.026	.327
	Lower-bound	171.500	1.000	171.500	6.307	.026	.327
Error(cond)	Sphericity Assumed	353.500	13	27.192			
	Greenhouse-Geisser	353.500	13.000	27.192			
	Huynh-Feldt	353.500	13.000	27.192			
	Lower-bound	353.500	13.000	27.192			
intervention * cond	Sphericity Assumed	164.571	1	164.571	9.885	.008	.432
	Greenhouse-Geisser	164.571	1.000	164.571	9.885	.008	.432
	Huynh-Feldt	164.571	1.000	164.571	9.885	.008	.432
	Lower-bound	164.571	1.000	164.571	9.885	.008	.432
Error(intervention*cond)	Sphericity Assumed	216.429	13	16.648			
	Greenhouse-Geisser	216.429	13.000	16.648			
	Huynh-Feldt	216.429	13.000	16.648			
	Lower-bound	216.429	13.000	16.648			

WASI Performance

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	138.286	1	138.286	.172	.685	.013
	Greenhouse-Geisser	138.286	1.000	138.286	.172	.685	.013
	Huynh-Feldt	138.286	1.000	138.286	.172	.685	.013
	Lower-bound	138.286	1.000	138.286	.172	.685	.013
Error(intervention)	Sphericity Assumed	10434.214	13	802.632			
	Greenhouse-Geisser	10434.214	13.000	802.632			
	Huynh-Feldt	10434.214	13.000	802.632			
	Lower-bound	10434.214	13.000	802.632			
cond	Sphericity Assumed	1716.071	1	1716.071	6.142	.028	.321
	Greenhouse-Geisser	1716.071	1.000	1716.071	6.142	.028	.321
	Huynh-Feldt	1716.071	1.000	1716.071	6.142	.028	.321
	Lower-bound	1716.071	1.000	1716.071	6.142	.028	.321
Error(cond)	Sphericity Assumed	3632.429	13	279.418			
	Greenhouse-Geisser	3632.429	13.000	279.418			
	Huynh-Feldt	3632.429	13.000	279.418			
	Lower-bound	3632.429	13.000	279.418			
intervention * cond	Sphericity Assumed	5.786	1	5.786	.019	.892	.001
	Greenhouse-Geisser	5.786	1.000	5.786	.019	.892	.001
	Huynh-Feldt	5.786	1.000	5.786	.019	.892	.001
	Lower-bound	5.786	1.000	5.786	.019	.892	.001
Error(intervention*cond)	Sphericity Assumed	3930.714	13	302.363			
	Greenhouse-Geisser	3930.714	13.000	302.363			
	Huynh-Feldt	3930.714	13.000	302.363			
	Lower-bound	3930.714	13.000	302.363			

Independent t-test

Satisfaction scores

Group Statistics

	groups	N	Mean	Std. Deviation	Std. Error Mean
Overall Satisfaction Score	ds	18	28.7222	6.48805	1.52925
	book	22	24.5455	5.03064	1.07254

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Overall Satisfaction Score	Equal variances assumed	1.345	.253
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means		
		t	df	Sig. (2-tailed)
Overall Satisfaction Score	Equal variances assumed	2.294	38	.027
	Equal variances not assumed	2.236	31.640	.033

Independent Samples Test

		t-test for Equality of Means	
		Mean Difference	Std. Error Difference
Overall Satisfaction Score	Equal variances assumed	4.17677	1.82069
	Equal variances not assumed	4.17677	1.86787

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Overall Satisfaction Score	Equal variances assumed	.49098	7.86256
	Equal variances not assumed	.37035	7.98319

Chi-Square

Effect of Condition on rate of Completion of Study

condition * finished Crosstabulation

			finished		
			yes	no	Total
condition	ds	Count	18	11	29
		Expected Count	16.6	12.4	29.0
		% within condition	62.1%	37.9%	100.0%
		% within finished	45.0%	36.7%	41.4%
		% of Total	25.7%	15.7%	41.4%
	book	Count	22	19	41
		Expected Count	23.4	17.6	41.0
		% within condition	53.7%	46.3%	100.0%
		% within finished	55.0%	63.3%	58.6%
		% of Total	31.4%	27.1%	58.6%
Total		Count	40	30	70
		Expected Count	40.0	30.0	70.0
		% within condition	57.1%	42.9%	100.0%
		% within finished	100.0%	100.0%	100.0%
		% of Total	57.1%	42.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.491[a]	1	.484		
Continuity Correction[b]	.207	1	.649		
Likelihood Ratio	.493	1	.483		
Fisher's Exact Test				.625	.325
Linear-by-Linear Association	.484	1	.487		
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.43.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.491[a]	1	.484		
Continuity Correction[b]	.207	1	.649		
Likelihood Ratio	.493	1	.483		
Fisher's Exact Test				.625	.325
Linear-by-Linear Association	.484	1	.487		
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.43.

b. Computed only for a 2x2 table

Effect of testing category on rate of Completion of Study

pretest * condition Crosstabulation

			condition		Total
			ds	book	
pretest	yes	Count	19	25	44
		Expected Count	18.2	25.8	44.0
		% within pretest	43.2%	56.8%	100.0%
		% within condition	65.5%	61.0%	62.9%
		% of Total	27.1%	35.7%	62.9%
	no	Count	10	16	26
		Expected Count	10.8	15.2	26.0
		% within pretest	38.5%	61.5%	100.0%
		% within condition	34.5%	39.0%	37.1%
		% of Total	14.3%	22.9%	37.1%
Total		Count	29	41	70
		Expected Count	29.0	41.0	70.0
		% within pretest	41.4%	58.6%	100.0%
		% within condition	100.0%	100.0%	100.0%
		% of Total	41.4%	58.6%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.150[a]	1	.698		
Continuity Correction[b]	.019	1	.892		
Likelihood Ratio	.151	1	.698		
Fisher's Exact Test				.804	.447
Linear-by-Linear Association	.148	1	.701		
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.77.

b. Computed only for a 2x2 table

Appendix M: Student Consent Form

Dear participant,

My name is Kevin Power and I am a postgraduate student in Dun Laoghaire Institute of Art Design and Technology (IADT). I am researching Cognitive Skills Improvements using technological and text-based skills training tools. Participants consenting to take part in the study will be given a screening test to evaluate the eligibility for the study. Eligible participants could be asked to take the following tests:

- A numeracy test rating skill levels in arithmetic lasting ten minutes.
- The MAC-S measuring memory abilities and the Raven's Standard Progressive Matrices measuring intelligence. Both tests lasting approximately forty minutes each.

Participants will then be asked to use either Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain") or Dr Kawashima's *Brain Training* on the Nintendo DS Console 10 minutes every day for a thirty days. After the thirty day period the numeracy test, MAC-S and the Raven's Standard Progressive Matrices will again be administered.

All data obtained will be treated with full anonymity and confidentiality and no individual participant will be identifiable if published. You are free to decline to answer any question, and are free to withdraw from the study at any time and all corresponding data will be destroyed. The welfare of participants is of the utmost importance to me and my supervisors.

I would be most grateful if you would consider taking part in this study. If you have any questions regarding this study, please do not hesitate to contact me. My email address is kevin.power@iadt.ie. Alternatively, if you wish to contact my supervisors, you can contact Dr Grainne Kirwan at grainne.kirwan@iadt.ie or Ms. Marion Palmer at marion.palmer@iadt.ie .

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Appendix N: Student Screening Questionnaire

Screening Questionnaire

Please complete all sections of this using a black pen.
Do not leave sections blank.

Please circle
Gender: Male Female

Age: _____

Please circle your level of confidence in your ability to complete each task along a scale of 1 – 5.

Examples of typical responses at each level are given below.

6 I am not aware of this.

7 I am aware of this but not experienced in using/implementing it.

8 I have used/done this occasionally but need further practice/training to be confident.

9 I am a regular and confident user of this.

10 I am fully competent with this and could confidently explain it to others.

Activities					
• Do Crossword or Word Search	1	2	3	4	5
• Do Sudoku	1	2	3	4	5
• Play Card Games e.g. Bridge	1	2	3	4	5
• Read Books which actively challenge the brain for example	1	2	3	4	5
• Used Kawashima's (2007) "Train Your Brain: 60 Days to a Better Brain")	1	2	3	4	5
Nintendo DS Lite Console					
• Have used the console	1	2	3	4	5
• Played Dr Kawashima's *Brain Training*	1	2	3	4	5
• Played other *Brain Training* games e.g. BrainAge	1	2	3	4	5
Using the Internet					
• Access an Internet site via its website address	1	2	3	4	5
• Use search engines to find information	1	2	3	4	5
• Use bookmarks / favourites for marking sites	1	2	3	4	5
• Download files from the internet	1	2	3	4	5
E-mail					
• Send and receive e-mail messages	1	2	3	4	5
• Attach files to outgoing e-mails	1	2	3	4	5
• Open and save files attached to incoming e-mails	1	2	3	4	5
• Create new contacts in address book	1	2	3	4	5
Word Processing					
• Use simple editing e.g. bold, italics, centering, font size etc	1	2	3	4	5
• Use a spellchecker	1	2	3	4	5
• Import text and images into a word processed document	1	2	3	4	5
• Include tables in a document	1	2	3	4	5
• Lay out text and images	1	2	3	4	5
• Prepare a simple document	1	2	3	4	5
Computer Management					
• Locate and run a programme (software application)	1	2	3	4	5
• Organise your electronic files into folders	1	2	3	4	5
• Search for files on the computer system	1	2	3	4	5
• Move files between drives (e.g. from A: to I)	1	2	3	4	5
• Prepare a simple document	1	2	3	4	5

Appendix O: Participant Debrief

Title of Study: Evaluation of Cognitive Skills Improvements using technological and text-based skills training tools

Thank you for taking part in this study. The aims of this study are to assess the effectiveness of skills training tools, and to determine if technological or text bases tools are more effective.

If you would like any information about the results of the study once it is completed, or if you have any questions or queries about the study, please feel free to contact me. Tel. +353 (1) 2144933 or email: kevin.power@iadt.ie.

Alternatively, if you wish to contact my supervisors, you can contact Dr Grainne Kirwan at grainne.kirwan@iadt or Dr Marion Palmer at marion.palmer@iadt.ie.

Appendix P: Student Study SPSS Data Output

Within-Subjects ANOVA

NAT

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	7.364	1	7.364	.005	.944	.001
	Greenhouse-Geisser	7.364	1.000	7.364	.005	.944	.001
	Huynh-Feldt	7.364	1.000	7.364	.005	.944	.001
	Lower-bound	7.364	1.000	7.364	.005	.944	.001
Error(intervention)	Sphericity Assumed	14047.636	10	1404.764			
	Greenhouse-Geisser	14047.636	10.000	1404.764			
	Huynh-Feldt	14047.636	10.000	1404.764			
	Lower-bound	14047.636	10.000	1404.764			
cond	Sphericity Assumed	17520.091	1	17520.091	42.974	.000	.811
	Greenhouse-Geisser	17520.091	1.000	17520.091	42.974	.000	.811
	Huynh-Feldt	17520.091	1.000	17520.091	42.974	.000	.811
	Lower-bound	17520.091	1.000	17520.091	42.974	.000	.811
Error(cond)	Sphericity Assumed	4076.909	10	407.691			
	Greenhouse-Geisser	4076.909	10.000	407.691			
	Huynh-Feldt	4076.909	10.000	407.691			
	Lower-bound	4076.909	10.000	407.691			
intervention * cond	Sphericity Assumed	168.091	1	168.091	.668	.433	.063
	Greenhouse-Geisser	168.091	1.000	168.091	.668	.433	.063
	Huynh-Feldt	168.091	1.000	168.091	.668	.433	.063
	Lower-bound	168.091	1.000	168.091	.668	.433	.063
Error(intervention*cond)	Sphericity Assumed	2514.909	10	251.491			
	Greenhouse-Geisser	2514.909	10.000	251.491			
	Huynh-Feldt	2514.909	10.000	251.491			
	Lower-bound	2514.909	10.000	251.491			

MAC-S Total

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	40.091	1	40.091	.325	.581	.031
	Greenhouse-Geisser	40.091	1.000	40.091	.325	.581	.031
	Huynh-Feldt	40.091	1.000	40.091	.325	.581	.031
	Lower-bound	40.091	1.000	40.091	.325	.581	.031
Error(intervention)	Sphericity Assumed	1234.409	10	123.441			
	Greenhouse-Geisser	1234.409	10.000	123.441			
	Huynh-Feldt	1234.409	10.000	123.441			
	Lower-bound	1234.409	10.000	123.441			
cond	Sphericity Assumed	837.818	1	837.818	9.150	.013	.478
	Greenhouse-Geisser	837.818	1.000	837.818	9.150	.013	.478
	Huynh-Feldt	837.818	1.000	837.818	9.150	.013	.478
	Lower-bound	837.818	1.000	837.818	9.150	.013	.478
Error(cond)	Sphericity Assumed	915.682	10	91.568			
	Greenhouse-Geisser	915.682	10.000	91.568			
	Huynh-Feldt	915.682	10.000	91.568			
	Lower-bound	915.682	10.000	91.568			
intervention * cond	Sphericity Assumed	76.455	1	76.455	2.172	.171	.178
	Greenhouse-Geisser	76.455	1.000	76.455	2.172	.171	.178
	Huynh-Feldt	76.455	1.000	76.455	2.172	.171	.178
	Lower-bound	76.455	1.000	76.455	2.172	.171	.178
Error(intervention*cond)	Sphericity Assumed	352.045	10	35.205			
	Greenhouse-Geisser	352.045	10.000	35.205			
	Huynh-Feldt	352.045	10.000	35.205			
	Lower-bound	352.045	10.000	35.205			

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	12.023	1	12.023	.682	.428	.064
	Greenhouse-Geisser	12.023	1.000	12.023	.682	.428	.064
	Huynh-Feldt	12.023	1.000	12.023	.682	.428	.064
	Lower-bound	12.023	1.000	12.023	.682	.428	.064
Error(intervention)	Sphericity Assumed	176.227	10	17.623			
	Greenhouse-Geisser	176.227	10.000	17.623			
	Huynh-Feldt	176.227	10.000	17.623			
	Lower-bound	176.227	10.000	17.623			
cond	Sphericity Assumed	.205	1	.205	.157	.700	.015
	Greenhouse-Geisser	.205	1.000	.205	.157	.700	.015
	Huynh-Feldt	.205	1.000	.205	.157	.700	.015
	Lower-bound	.205	1.000	.205	.157	.700	.015
Error(cond)	Sphericity Assumed	13.045	10	1.305			
	Greenhouse-Geisser	13.045	10.000	1.305			
	Huynh-Feldt	13.045	10.000	1.305			
	Lower-bound	13.045	10.000	1.305			
intervention * cond	Sphericity Assumed	.205	1	.205	.157	.700	.015
	Greenhouse-Geisser	.205	1.000	.205	.157	.700	.015
	Huynh-Feldt	.205	1.000	.205	.157	.700	.015
	Lower-bound	.205	1.000	.205	.157	.700	.015
Error(intervention*cond)	Sphericity Assumed	13.045	10	1.305			
	Greenhouse-Geisser	13.045	10.000	1.305			
	Huynh-Feldt	13.045	10.000	1.305			
	Lower-bound	13.045	10.000	1.305			

MAC-S Part B

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	1.841	1	1.841	.012	.915	.001
	Greenhouse-Geisser	1.841	1.000	1.841	.012	.915	.001
	Huynh-Feldt	1.841	1.000	1.841	.012	.915	.001
	Lower-bound	1.841	1.000	1.841	.012	.915	.001
Error(intervention)	Sphericity Assumed	1518.909	10	151.891			
	Greenhouse-Geisser	1518.909	10.000	151.891			
	Huynh-Feldt	1518.909	10.000	151.891			
	Lower-bound	1518.909	10.000	151.891			
cond	Sphericity Assumed	156.568	1	156.568	4.523	.059	.311
	Greenhouse-Geisser	156.568	1.000	156.568	4.523	.059	.311
	Huynh-Feldt	156.568	1.000	156.568	4.523	.059	.311
	Lower-bound	156.568	1.000	156.568	4.523	.059	.311
Error(cond)	Sphericity Assumed	346.182	10	34.618			
	Greenhouse-Geisser	346.182	10.000	34.618			
	Huynh-Feldt	346.182	10.000	34.618			
	Lower-bound	346.182	10.000	34.618			
intervention * cond	Sphericity Assumed	2.750	1	2.750	.105	.753	.010
	Greenhouse-Geisser	2.750	1.000	2.750	.105	.753	.010
	Huynh-Feldt	2.750	1.000	2.750	.105	.753	.010
	Lower-bound	2.750	1.000	2.750	.105	.753	.010
Error(intervention*cond)	Sphericity Assumed	262.000	10	26.200			
	Greenhouse-Geisser	262.000	10.000	26.200			
	Huynh-Feldt	262.000	10.000	26.200			
	Lower-bound	262.000	10.000	26.200			

MAC-S Part C

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	46.023	1	46.023	.229	.643	.022
	Greenhouse-Geisser	46.023	1.000	46.023	.229	.643	.022
	Huynh-Feldt	46.023	1.000	46.023	.229	.643	.022
	Lower-bound	46.023	1.000	46.023	.229	.643	.022
Error(intervention)	Sphericity Assumed	2012.227	10	201.223			
	Greenhouse-Geisser	2012.227	10.000	201.223			
	Huynh-Feldt	2012.227	10.000	201.223			
	Lower-bound	2012.227	10.000	201.223			
cond	Sphericity Assumed	378.205	1	378.205	19.391	.001	.660
	Greenhouse-Geisser	378.205	1.000	378.205	19.391	.001	.660
	Huynh-Feldt	378.205	1.000	378.205	19.391	.001	.660
	Lower-bound	378.205	1.000	378.205	19.391	.001	.660
Error(cond)	Sphericity Assumed	195.045	10	19.505			
	Greenhouse-Geisser	195.045	10.000	19.505			
	Huynh-Feldt	195.045	10.000	19.505			
	Lower-bound	195.045	10.000	19.505			
intervention * cond	Sphericity Assumed	24.750	1	24.750	1.452	.256	.127
	Greenhouse-Geisser	24.750	1.000	24.750	1.452	.256	.127
	Huynh-Feldt	24.750	1.000	24.750	1.452	.256	.127
	Lower-bound	24.750	1.000	24.750	1.452	.256	.127
Error(intervention* cond)	Sphericity Assumed	170.500	10	17.050			
	Greenhouse-Geisser	170.500	10.000	17.050			
	Huynh-Feldt	170.500	10.000	17.050			
	Lower-bound	170.500	10.000	17.050			

Raven's SPM Grade

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	1.841	1	1.841	2.664	.134	.210
	Greenhouse-Geisser	1.841	1.000	1.841	2.664	.134	.210
	Huynh-Feldt	1.841	1.000	1.841	2.664	.134	.210
	Lower-bound	1.841	1.000	1.841	2.664	.134	.210
Error(intervention)	Sphericity Assumed	6.909	10	.691			
	Greenhouse-Geisser	6.909	10.000	.691			
	Huynh-Feldt	6.909	10.000	.691			
	Lower-bound	6.909	10.000	.691			
cond	Sphericity Assumed	.023	1	.023	.132	.724	.013
	Greenhouse-Geisser	.023	1.000	.023	.132	.724	.013
	Huynh-Feldt	.023	1.000	.023	.132	.724	.013
	Lower-bound	.023	1.000	.023	.132	.724	.013
Error(cond)	Sphericity Assumed	1.727	10	.173			
	Greenhouse-Geisser	1.727	10.000	.173			
	Huynh-Feldt	1.727	10.000	.173			
	Lower-bound	1.727	10.000	.173			
intervention * cond	Sphericity Assumed	.205	1	.205	1.324	.277	.117
	Greenhouse-Geisser	.205	1.000	.205	1.324	.277	.117
	Huynh-Feldt	.205	1.000	.205	1.324	.277	.117
	Lower-bound	.205	1.000	.205	1.324	.277	.117
Error(intervention*cond)	Sphericity Assumed	1.545	10	.155			
	Greenhouse-Geisser	1.545	10.000	.155			
	Huynh-Feldt	1.545	10.000	.155			
	Lower-bound	1.545	10.000	.155			

Raven's SPM Score

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
intervention	Sphericity Assumed	46.023	1	46.023	1.467	.254	.128
	Greenhouse-Geisser	46.023	1.000	46.023	1.467	.254	.128
	Huynh-Feldt	46.023	1.000	46.023	1.467	.254	.128
	Lower-bound	46.023	1.000	46.023	1.467	.254	.128
Error(intervention)	Sphericity Assumed	313.727	10	31.373			
	Greenhouse-Geisser	313.727	10.000	31.373			
	Huynh-Feldt	313.727	10.000	31.373			
	Lower-bound	313.727	10.000	31.373			
cond	Sphericity Assumed	8.205	1	8.205	.916	.361	.084
	Greenhouse-Geisser	8.205	1.000	8.205	.916	.361	.084
	Huynh-Feldt	8.205	1.000	8.205	.916	.361	.084
	Lower-bound	8.205	1.000	8.205	.916	.361	.084
Error(cond)	Sphericity Assumed	89.545	10	8.955			
	Greenhouse-Geisser	89.545	10.000	8.955			
	Huynh-Feldt	89.545	10.000	8.955			
	Lower-bound	89.545	10.000	8.955			
intervention * cond	Sphericity Assumed	1.841	1	1.841	.222	.648	.022
	Greenhouse-Geisser	1.841	1.000	1.841	.222	.648	.022
	Huynh-Feldt	1.841	1.000	1.841	.222	.648	.022
	Lower-bound	1.841	1.000	1.841	.222	.648	.022
Error(intervention*cond)	Sphericity Assumed	82.909	10	8.291			
	Greenhouse-Geisser	82.909	10.000	8.291			
	Huynh-Feldt	82.909	10.000	8.291			
	Lower-bound	82.909	10.000	8.291			

Independent t-test

Satisfaction

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Overall Satisfaction Score	ds	14	20.5000	5.48775	1.46666
	book	11	22.3636	7.31126	2.20443

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Overall Satisfaction Score	Equal variances assumed	2.419	.134
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means		
		t	df	Sig. (2-tailed)
Overall Satisfaction Score	Equal variances assumed	-.729	23	.473
	Equal variances not assumed	-.704	18.086	.490

Independent Samples Test

	t-test for Equality of Means

		Mean Difference	Std. Error Difference
Overall Satisfaction Score	Equal variances assumed	-1.86364	2.55659
	Equal variances not assumed	-1.86364	2.64775

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Overall Satisfaction Score	Equal variances assumed	-7.15236	3.42508
	Equal variances not assumed	-7.42446	3.69718

Appendix Q: Older Adult Dropout Technological Focus Group

A1 FOCUS GROUP INTERVIEW

Good afternoon, some of you might know me but for those who don't, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training*. I have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 50 minutes.

Introduce assistant –

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 2 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies -- one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

1.10 p.m. (approx) Moderator

1. Lead: Could you describe what you liked or disliked about the game?

Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses, calculations.

Prompt: How did you find the word Memorization test?

Prompt: How did you find speaking aloud to the console?

Prompt: Did using the game feel like homework?

1.20 p.m. Moderator

2. Lead. Do you feel you have benefited from using the game?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt: Did you show improvement in the calculations?

Prompt. Alternatively do you feel you have not benefited from using the game?

Prompt: In what way?

Prompt. Would you like to try the work book version of the game?

1.30 p.m Moderator

3 Lead. Why did you stop using the game?

Prompt: Did you find yourself starting and stopping using the game often?

Prompt: Did you find it boring/frustrating?

Prompt: Did you lose interest?

Prompt: Unrelated to the game e.g. death in the family?

1.40 p.m Moderator

4. . Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

Prompt: Is it beneficial?

Prompt: In what way?

1.45 p.m Moderator

5. Lead. Do you have any comments about the game?

Prompt: Were the instructions given good enough?

Prompt: What did you think of Dr Kawashima's tips?

Prompt: Was it easy to use?

1.50 p.m Moderator

6. Lead. Do you feel using the game will benefit you in everyday life in the future?

Prompt: Do you feel any difference when, telling the time, remembering appointments?

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

2.00 p.m CLOSE

Appendix R: Older Adults Dropout Text-based Focus Group

A2 FOCUS GROUP INTERVIEW

Good afternoon, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course here as well. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training* software and text book and have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 50 minutes.

Introduce assistant – Deidre Kelly

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 3 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies – one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

2.10 p.m. (approx) Moderator

1. Lead: Could you describe what you liked or disliked about the book?

Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 - 120, stroop test?

Prompt: How did you find the word Memorization test?

Prompt: Did using the book feel like homework?

2.20 p.m. Moderator

2. Lead. Do you feel you have benefited from using the book?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt: Did you show improvement in the calculations?

Prompt. Alternatively do you feel you have not benefited from using the book?

Prompt: In what way?

Prompt. Would you like to try the Nintendo ds Lite game version of the book?

2.30 p.m Moderator

3 Lead. Why did you stop using the book?

Prompt: Did you find yourself starting and stopping using the book often?

Prompt: Did you find it boring/frustrating?

Prompt: Did you lose interest?

Prompt: Unrelated to the book e.g. death in the family?

2.40 **p.m Moderator**

4. Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

Prompt: Is it beneficial?

Prompt: In what way?

2.45 **p.m Moderator**

5. Lead. Do you have any comments about the book?

Prompt: Were the instructions given good enough?

Prompt. Some people commented that the book would not stay open did you find this?

Prompt: Would a ring binder have solved this problem?

Prompt: Did you use a stop watch to time yourself?

Prompt: Did you buy a stop watch?

2.50 p.m Moderator

6. Lead. Do you feel using the book will benefit you in everyday life in the future?

Prompt: Do you feel any difference when, telling the time, remembering appointments?

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

3.00 p.m CLOSE

Appendix S: Older Adults Completer Technological Focus Group

B1 FOCUS GROUP INTERVIEW

Good afternoon, some of you might know me but for those who don't, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training*. I have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 45 minutes.

Introduce assistant – Tara Kehoe

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 3 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies – one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

Moderator

1. Lead: Could you describe what you liked or disliked about the game?

Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses, calculations.

Prompt: How did you find the word Memorization test?

Prompt: How did you find speaking aloud to the console?

Prompt: Did using the game feel like homework?

Prompt: Did using the game require diligence?

Moderator

2. Lead. Do you feel you have benefited from using the game?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt: Did you show improvement in the calculations?

Prompt. Alternatively do you feel you have not benefited from using the game?

Prompt: In what way?

Prompt. Would you like to try the work book version of the game?

Moderator

3 Lead. How would you improve the game?

Prompt: Would you change the screen size?

Prompt: Would you improve the voice recognition?

Moderator

4. . Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

Prompt: Is it beneficial?

Prompt: In what way?

Moderator

5. Lead. Do you have any comments about the game?

Prompt: Were the instructions given good enough?

Prompt: What did you think of Dr Kawashima's tips?

Prompt: Was it easy to use?

Moderator

6. Lead. Do you feel using the game will benefit you in everyday life in the future?

Prompt: Do you feel any difference when, telling the time, remembering appointments?

Prompt: If so do you still feel these benefits?

Thoughts/Opinions

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

2.00 p.m CLOSE

Appendix T: Older Adults Completer Text-based Focus Group

B2 FOCUS GROUP INTERVIEW

Good afternoon, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course here as well. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training* software and text book and have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 45 minutes.

Introduce assistant – Tara Kehoe

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 1.30 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies – one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

Moderator

1. Lead: Could you describe what you liked or disliked about the book?

Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 - 120, stroop test?

Prompt: How did you find the word Memorization test?

Prompt: Did using the book feel like homework?

Prompt: Did using the book require diligence?

Moderator

2. Lead. Do you feel you have benefited from using the book?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt: Did you show improvement in the calculations?

Prompt. Alternatively do you feel you have not benefited from using the book?

Prompt: In what way?

Prompt. Would you like to try the Nintendo ds Lite game version of the book?

Moderator

3 Lead. How would you improve the book?

Prompt. Some people commented that the book would not stay open did you find this?

Prompt: Would you prefer a ring binder??

Prompt: Did you use a stop watch to time yourself

Prompt: Would have liked an incorporated stopwatch?

Moderator

4. Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

Prompt: Is it beneficial?

Prompt: In what way?

Moderator

5. Lead. Do you have any other comments about the book?

Prompt: Were the instructions given good enough?

Prompt: Was it easy to use?

Moderator

6. Lead. Do you feel using the book will benefit you in everyday life in the future?

Prompt: Do you feel any difference when, telling the time, remembering appointments?

Prompt: If so do you still feel these benefits?

Thoughts/Opinions

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

3.00 p.m CLOSE

Appendix U: Undergrad Students Technological Focus Group

C1 STUDENT FOCUS GROUP INTERVIEW

Good afternoon, some of you might know me but for those who don't, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training*. I have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 40 minutes.

Introduce assistant – Deidre Kelly

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 2 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies – one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

1.10 p.m. (approx) Moderator

1. Lead: Could you describe what you liked or disliked about the game?

Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses.

1.20 p.m. Moderator

2. Lead. Do you feel you have benefited from using the game?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt. Alternatively do you feel you have not benefited from using the game?

Prompt. Would you like to try the work book version of the game?

1.30 p.m Moderator

3. Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

Prompt: Is it beneficial?

Prompt: In what way?

1.40 p.m Moderator

4. Lead. Do you feel using the game will benefit you in everyday life in the future?

Prompt: Do you feel any difference when, telling the time, remembering appointments?

1.50 p.m Moderator

5. Lead. What did you like/dislike about the study?

Prompt. Is there any way in which the researcher could have made the study easier for you?

1.55 p.m Moderator

Lead. Did other people e.g. friend, spouse comment about you progress?

Prompt. Have other people showed an interest in using the game after talking to you?

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

2.00 p.m CLOSE

Appendix V: Undergrad Students Text-based Focus Group

C2 STUDENT FOCUS GROUP INTERVIEW

Good afternoon, some of you might know me but for those who don't, I am Kevin Power and I'm a full-time Masters by Research student here in IADT. I am also a graduate from the 'Psychology applied to IT' course here as well. I am researching the use of cognitive skills training tools namely Dr Kawashima's *Brain Training* software and text book and have asked you here today to gain some input from your experiences and opinions on the subject.

My role today is one of researcher/facilitator for this group discussion. It will last for approximately 40 minutes.

Introduce assistant – Deirdre Kelly

The order of the meeting is as follows

Short introduction about the meeting and what today is all about
Some housekeeping details – timing
Filling in of CONSENT forms
Then we will start the discussion
I will then close the session at precisely 2 p.m.

I will try to keep the session as informal as possible.

Is there anything about the format of this focus group interview you would like clarification on?

Before we begin can I say that it is important that the data collected today is with your full permission and consequently I would like you all to sign the consent forms that I have here. There are two copies – one for your own records and one to be handed back to me as researcher.

On the form you will see that I am also requesting that this interview be recorded. This is to facilitate further analysis by me only.

1.15 p.m. (approx) Moderator

1. Lead: Could you describe what you liked or disliked about the book?

Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 – 120, stroop test?

Prompt: Did using the book feel like homework?

1.25 p.m. Moderator

2. Lead. Do you feel you have benefited from using the book?

Prompt. If so what kind of benefits do you feel you have gained?

Prompt. Alternatively do you feel you have not benefited from using the book?

Prompt. Do you feel using the book will benefit you in everyday life in the future?

Prompt. Would you like to try the Nintendo ds Lite game version of the book?

Prompt: Is it beneficial?

Prompt: In what way?

1.35 p.m Moderator

3. Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

1.45 p.m Moderator

4. Lead. Did other people e.g. friend, spouse comment about you progress?

Prompt. Have other people showed an interest in using the book after talking to you?

1.50 p.m Moderator

5. Lead. What did you like/dislike about the study?

Prompt. Is there any way in which the researcher could have made the study easier for you?

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

2.00 p.m CLOSE

Appendix W: Focus Group Consent Form

FOCUS GROUP CONSENT FORM

Dear participant,

You are being asked to participate in an open group discussion regarding the use of *Brain Training* software/ text book. This is to facilitate my research into the area of *Brain Training*.

Any information provided by you in this discussion will be completely confidential and anonymity will be guaranteed to you at all times throughout this research. You are also free to withdraw from the study at any time and have any of your information destroyed. The information you do provide however, will be used for research purposes only.

I also request your permission for this discussion to be recorded. This is to facilitate further analysis by me only.

If you have any further questions, please do not hesitate to ask me.

Please tick the 'Yes' box to indicate you are giving your informed consent to participate in this research, otherwise tick 'No'.

☐ Yes No ☐

Signed: _____

Appendix X: Focus Group Debrief

Focus Group Debrief

Title of Study: Evaluation of Cognitive Skills Improvements using technological and text-based skills training tools

Thank you for taking part in this Focus Group. The aims of this Focus group are to gain some input from participants regarding your ideas and experiences from taking part in this study.

If you would like any information about the results of the study once it is completed, or if you have any questions or queries about the study, please feel free to contact me. Tel. +353 (1) 2144933 or email: kevin.power@iadt.ie.

Alternatively, if you wish to contact my supervisors, you can contact Dr Grainne Kirwan at grainne.kirwan@iadt or Dr Marion Palmer at marion.palmer@iadt.ie.

Appendix Y: Older Adult Dropout Technological Intervention Focus Group

1. Lead: Could you describe what you liked or disliked about the game?

Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses, calculations.

GP1: Initial feelings of repetition, I first saw the game used by children.

GP2: A lot of older people are frightened of technology. I wasn't frightened of the Nintendo DS.

Prompt: How did you find speaking aloud to the console?

The Stroop test wouldn't respond and I had to keep shouting at it.

GP1: I would write a number one but the game would think it was a number seven and I couldn't change it. I felt I wasn't making the most of what was on offer. (calculations)

GP2: Felt that the training tasks were very good and think that it would help if you kept at it.

Notes - problems with voice recognition and number recognition. P1 put off the *Brain Training* game thinking it is a child's toy.

2. Lead. Do you feel you have benefited from using the game?

Prompt. If so what kind of benefits do you feel you have gained?

GP1: Something new not just a crossword.

GP2: It (nds) plays its part in *Brain Training*; imagine that it would be a good companion on a journey. I had little formal education and was unfamiliar with some mathematical symbols, addition, subtraction, multiplication. It did reawaken in my mind these symbols.

GP1: better to use in the morning.

GP2: Would do it three days at a time and then stop because was busy with other courses.

Notes – hard for GP2 to use continually, question of diligence. Reawakened knowledge of arithmetic symbols. Imagine that it would be a good companion on a journey.

Q: Did your brain age come down

GP1: Oh yes but I don't like bragging. (Good humour)

Prompt. Would you like to try the work book version of the game?

GP2: I like the technology version (showing preference for technology over text)

3. Lead. Why did you stop using the game?

GP2: had booked into a lot of courses and was very busy, if I had the time I would keep going to the next level.

Prompt: Unrelated to the game e.g. death in the family?

GP1: Family commitments – had to look after daughters family

Notes – reasons for quitting are not to do with using the nds

4. Lead. How do you feel about *Brain Training*?

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

GP2 Its like everything else your education is ongoing all the time – nb participant is interested in education

GP1: that's why you're in u3a

5. Lead. Do you have any comments about the game?

Prompt: Was it easy to use?

GP2: Voice recognition problems – I'd say black and it wouldn't change. This could have been due to low battery.

R: I ended up telling new participants not too use the Stroop game to avoid this problem.

GP1: How was reading aloud judged – participant showing interest in the game.

GP2: I use tweeting and blogging

6. Lead. Do you feel using the game will benefit you in everyday life in the future?

GP2: I think it's a great machine for what it stands for (*Brain Training*) it does train the brain.

GP1: It's stimulating

GP2: makes you aware it's an aid to *Brain Training* the more you use it the more confident you become and can reach higher levels. Older people are too often pointing the finger at young people but when you see the amount of help they give you.

Notes – technology bringing generations together. Participants find it stimulating

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

2.00 p.m CLOSE

Drop out Focus Group Game

Notes

1. Problems with voice recognition (Stroop test) and number recognition (calculations). P1 put off the *Brain Training* game thinking it is a child's toy.

2. Hard for p2 to use continually. Diligence: "Question of diligence". Reawakened knowledge of arithmetic symbols. Imagine that it would be a good companion on a journey.

3. Reasons for quitting are not to do with using the NDS rather to do with a busy life schedule and other commitments e.g. family. The researcher did not realize how busy the participants were.

4 Education is very important to the participants: "It's like everything else your education is ongoing all the time" "that's why you're in u3a".

5. More voice recognition problems. "I'd say black and it wouldn't change"

6. Technology bringing generations together. As younger people have something to teach the older generations. Participants find using *Brain Training* stimulating.

Phase 1: Coding

Code	**Domain**
DIL	Diligence
RISI	Relationship issues/ social influences
HSI	Hardware /Software Issues
EDI	Education Issues
ATT	Attitude to Technology
BT	*Brain Training*

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Persistence shown or lack thereof	Level of persistence using the CSTT exhibited by participant	Diligence
Family/schedule	Looking after a partner/ Looking after ones family/ holidays/ busy schedule	Relationship issues/ social influences
Problems using CSTT	Problems using CSTT related to hardware/software; problems with voice recognition/ using stylus to write numbers or words.	Hardware /Software Issues
Interest/educational aid	Aid to education/ Participants interested in Education	Education Issues
Attitude/awareness technology	Participants attitude to technology/ awareness of new technologies/ Helping to learn new technologies	Attitude to Technology
Attitudes to BT	Like/dislike BT, felt they worked/didn't work	*Brain Training*

Code	Specific FIB	Transcript Quotes	Themes
DIL	Level of persistence using the CSTT exhibited by participant	GP2: Felt that the training tasks were very good and think that it would help if you kept at it. GP2: Would do it three days at a time and then stop because was busy with other courses. GP2: makes you aware it's an aid to *Brain Training* the more you use it the more confident you become and can reach higher levels.	Diligence needed to progress further using the game
RISI	Looking after a partner/ Looking after ones family/ holidays/ busy schedule	GP1: Initial feelings of repetition, I first saw the game used by children, GP2: had booked into a lot of courses and was very busy, if I had the time I would keep going to the next level GP2: Would do it three days at a time and then stop because was busy with other courses. GP1: Family commitments – had to look after daughters family	Reasons for quitting the study are not related to problems using the game. Reasons for quitting the study are related to busy life schedule or family commitments.
HSI	Problems using CSTT related to hardware/software; problems with voice recognition/ using stylus to write numbers or words.	GP2: The Stroop test wouldn't respond and I had to keep shouting at it. GP1: I would write a number one but the game would think it was a number seven and I couldn't change it. GP2: I'd say black and it wouldn't change.	Ease of use of problems using the game. Reasons for quitting the study are not related to problems using the game.
EDI	Aid to education/ Participants interested in Education	P2: I had little formal education and was unfamiliar with some mathematical symbols, addition, subtraction, multiplication. It did reawaken in my mind these symbols. GP2: It's like everything else your education is ongoing all the time GP1: that's why you're in u3a	Interest in education
ATT	Participants attitude to technology/ awareness of new technologies/ Helping to learn new technologies	GP2: A lot of older people are frightened of technology. I wasn't frightened of the Nintendo DS. GP1: Something new not just a crossword. GP2: I like the technology version GP1: How was reading aloud judged GP2: I use tweeting and blogging GP2: Older people are too often pointing the finger at young people but when you see the amount of help they give you.	Interest in new technologies
BT	Like/dislike BT, felt they worked/didn't work	GP1: I felt I wasn't making the most of what was on offer. GP2: Felt that the training tasks were very good and think that it would help if you kept at it. GP1: Something new not just a crossword.	*Brain Training* thought of positively *Brain Training* seen as a positive cognitive aid

		GP2: It (nds) plays its part in *Brain Training*; imagine that it would be a good companion on a journey. GP1: better to use in the morning GP1: How was reading aloud judged GP2: I think it's a great machine for what it stands for (*Brain Training*) it does train the brain. GP1: It's stimulating.	

Themes

The following themes were found on analysis of the drop out game focus group:

5. Diligence needed to progress further using the game
6. Reasons for quitting the study are not related to problems using the game. Reasons for quitting the study are related to busy life schedule or family commitments.
7. Ease of use of problems using the game.
8. Interest in education
9. Interest in new technologies
10. *Brain Training* seen as a positive cognitive aid

1. Diligence needed to progress further using the game

Participants felt that they could have made more progress and improvement had they used the game more regularly and for a longer period. This is evidenced by the following quotes; "Felt that the training tasks were very good and think that it would help if you kept at it", "Would do it three days at a time and then stop because was busy with other courses", "makes you aware it's an aid to *Brain Training* the more you use it the more confident you become and can reach higher levels".

2. Reasons for quitting the study are not related to problems using the game. Reasons for quitting the study are related to busy life schedule or family commitments.

One of the aims of this focus group was to discover participant's reasons for quitting the study. Problems using the game were noted by almost all participants that used the game however in relation to these participants the reasons for quitting the study related to busy life schedules and other family commitments. This is evidenced by the following quotes; GP2: "had booked into a lot of courses and was very busy,", "GP2: Would do it three days at a time and then stop because was busy with other courses", "GP1: Family commitments – had to look after daughters family".

3. Ease of use of problems using the game.

As has been previously stated many participants experienced problems using the *Brain Training* game. An emerging theme through this research has been of the ease of use problems experienced by participants. Problems were experienced using the voice recognition and using stylus to write numbers and/or words. This is evidenced by the following quotes; "GP2: The Stroop test wouldn't respond and I had to keep shouting at it", "GP1: I would write a number one but the game would think it was a number seven and I couldn't change it" , "GP2: I'd say black and it wouldn't change".

4. Interest in education

During this focus group another interesting theme that occurred was of the participant's interest in education. Participants viewed the *Brain Training* game as an aid to education.

Moreover participants viewed their own education as ongoing over the course of their entire lives. Both these participants were members of U3A groups an organization that espouses the value of education well into later life. This is evidenced by the following quotes; "GP2: I had little formal education and was unfamiliar with some mathematical symbols, addition, subtraction, multiplication. It (the *Brain Training* game) did reawaken in my mind these symbols." "GP2: It's like everything else your education is ongoing all the time", "GP1: that's why you're in u3a".

5. Interest in new technologies

Both participants interviewed expressed an interest in using a new technological tool that they had never used before. The participants were not afraid to use the *Brain Training* game. This would suggest that reasons for quitting the study did not relate to a fear or dislike of the *Brain Training* game. This is evidenced by the following quotes; "GP2: A lot of older people are frightened of technology. I wasn't frightened of the Nintendo DS", "P1: Something new not just a crossword", "GP2: I like the technology version","P1: How was reading aloud judged","GP2: I use tweeting and blogging","GP2: Older people are too often pointing the finger at young people but when you see the amount of help they give you".

6. *Brain Training* seen as a positive cognitive aid

Participant's expressed an interest in the *Brain Training* game. Quotes suggest that the *Brain Training* game is seen positively by the participants. The training tasks were thought to be "very good" and "stimulating". This is evidenced by the following quotes; "GP1: I felt I wasn't making the most of what was on offer.", "GP2: Felt that the training tasks were very good and think that it would help if you kept at it.", "P1: Something new not just a crossword", "GP2: It (nds) plays its part in *Brain Training*; imagine that it would be a good companion on a journey.","P1: better to use in the morning","GP1: How was reading aloud judged","GP2: I think it's a great machine for what it stands for (*Brain Training*) it does train the brain.", "GP1: It's stimulating.".

Appendix Z: Older Adult Dropout Text-based Intervention Focus Group

Focus Group A2

2.10 p.m. (approx) Moderator

1. Lead: Could you describe what you liked or disliked about the book?
Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 - 120, stroop test?

BP1: I liked the calculations and I started to improve.

BP2: For me it wasn't a case of liking it or disliking it, I didn't find it too difficult. I had to stop and think with the colours(Stroop test) in order to get them right. I found the maths reasonably easy. Coming in at two minutes or under.

BP1: started out at 5 minutes brought time down to 2.45. I can answer the questions quicker in my head than my hand can write them. (motor skills decline)

Notes

Calculation found easy

Stroop test more challenging

Decline in motor skills a problem for BP1

Prompt: How did you find the word Memorization test?

BP1: Middling (Laughs)
BP2: Hard to find a link (to link up the words to help you remember)

Prompt: Did using the book feel like homework?

BP1: No

BP2: tried to do it after breakfast in the morning, and tended to stand at the counter (in the kitchen) so there would be minimum distractions. Was interrupted by my wife who has dementia that would break my concentration. Kept being interrupted so i stopped and started. Felt guilty letting you down. (participant really tried to use the book)

Notes

BP2 wife with dementia was main reason for finishing

2.20 p.m. Moderator

2. Lead. Do you feel you have benefited from using the book?
Prompt. If so what kind of benefits do you feel you have gained?
Prompt: Did you show improvement in the calculations?
Prompt. Alternatively do you feel you have not benefited from using the book?
Prompt: In what way?
Prompt. Would you like to try the Nintendo DS Lite game version of the book?

BP2: Did improve felt that I was helping my mental health. I felt that remembering a date came easier than usual. Theory of it could work.

BP1: I would be tempted to get a book.

BP2: The reason people don't use it is a question is a question of discipline to some extent. I would have to lock myself away to do it.

Notes BP2 felt improvements in everyday life

2.30 p.m Moderator

3. Lead. Why did you stop using the book?
Prompt: Did you find yourself starting and stopping using the book often?
Prompt: Did you find it boring/frustrating?

BP1: Found it frustrating my writing was too slow that frustrated me. Motor decline
BP2: you have to remain focused, can't have distractions, if the doorbell/phone rings, radio in background.
BP1: it definitely did stimulate the brain. Other factors not the 2 month time period for quitting.
BP2: I enjoyed it.
BP1: Wouldn't necessarily give up.
Prompt: did the fact the pages of the book flip over annoy you?
BP1: yes
BP2: I agree it (book) could have been better
BP1: A ring binder would have made it a lot easier
BP2: I used my phone for a stopwatch. Found counting aloud very easy. The Stroop test kept you on your toes really tested you

Notes – suggest ring binder in discussion as an improvement. Decline in motor skills may cause distress to participants using the book or game. Some people can have the answer to questions quicker than they are able to write.

4. Lead. How do you feel about *Brain Training*?
5. Lead. Do you have any comments about the book?

2.50 p.m Moderator

6. Lead. Do you feel using the book will benefit you in everyday life in the future?
Prompt: Do you feel any difference when, telling the time, remembering appointments?
BP2: To a degree, I recognise the beneficial effect. Did feel an improvement in alertness has a similar effect to Transcendental meditation. Requires a great application

Notes P2 try to look at links if any to effects of transcendental meditation

Moderator
How could I help people to keep up the *Brain Training*?
BP1: Calling people brings them back to square one.
BP2: As well as u3a I'm on 2 or 3 other committees (very busy)
BP2: When I look back I wonder how I found the time to go to work before I was retired. – This quote illustrates how busy u3a members are.
BP1: on Tuesday I'm organising a golf outing and then a meeting on Friday – also very busy.

Notes: Population I picked are very busy

Thoughts/Opinions on Quantitative Study…

Conclusion and Debrief

Review of study, management of data and reiteration of option to withdraw

Thank you for your time and attention.

I have enjoyed this discussion.

3.00 p.m CLOSE

Phase 1: Coding

Code	Domain
DIL	Diligence
RISI	Relationship issues/ social influences
PB	Problems using Book
BT	*Brain Training*
DMA	Decline in Motor Abilities

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Persistence shown or lack thereof	Level of persistence using the CSTT exhibited by participant	Diligence
Family/schedule	Looking after a partner/ Looking after ones family/ holidays/ busy schedule	Relationship issues/ social influences
Problems using CSTT	Problems using CSTT related; problems with turning pages, timing, colours.	Problems using book
Attitudes to BT	Like/dislike BT, felt they worked/didn't work. Attitude to *Brain Training*.	*Brain Training*
DMA	Problems experienced when using the CSTT relating to motor abilities. Finding it hard to turn pages or write calculations quickly.	Decline in Motor Abilities

Categorizing FG Responses

Code	Specific FIB	FIB Domain	Transcript Quote	Themes
DIL	Level of persistence using the CSTT exhibited by participant	Diligence	BP2: The reason people don't use it is a question of discipline to some extent. BP2: you have to remain focused, can't have distractions, if the doorbell/phone rings, radio in background. BP2: Requires a great application BP1 (researcher) Calling people brings them back to square one.	In order to achieve results using the book diligence and an application are required.
RISI	Looking after a partner/ Looking after ones family/ holidays/ busy schedule	Relationship issues/ social influences	BP2: Was interrupted by my wife who has dementia that would break my concentration. Kept being interrupted so i stopped and started. Felt guilty letting you down. (participant really tried to use the book) BP2: I would have to lock myself away to do it. BP1: BT Other factors not the 2 month time period for quitting. BP1: Wouldn't necessarily give up BP2: As well as u3a I'm on 2 or 3 other committees BP2: When I look back I wonder how I found the time to go to work before I was retired. RISI – This quote illustrates how busy u3a members are. BP1: on Tuesday I'm organising a golf outing and then a meeting on Friday – also very busy.	Hard for participants to use the book with constant interruptions from family members. Other family commitments are more important. Participants are very busy. Reasons for quitting the study are related to busy life schedule or family commitments.
PB	Problems using CSTT related; problems with turning pages, timing, colours.	Problems using book	BP2: you have to remain focused, can't have distractions, if the doorbell/phone rings, radio in background. Prompt: did the fact the pages of the book flip over annoy you? BP1: yes PB BP2: I agree it (book) could have been better BP2: I used my phone for a stopwatch. BP1: A ring binder would have made it a lot easier BP2: Requires a great application	Easy to get distracted from using the book. Number of ease of use problems: pages flipping can't have distractions, no stopwatch provided.
BT	Like/dislike BT, felt they worked/didn't work. Attitude to *Brain Training*.	*Brain Training*	BP1: I liked the calculations and I started to improve BP2: For me it wasn't a case of liking it or disliking it, I didn't find it too difficult. BT I had to stop and think with the colours (Stroop test) in order to get them right.	Indifferent attitude to *Brain Training*. Also seen it as stimulating and

			I found the maths reasonably easy. Coming in at two minutes or under. BP2: Hard to find a link (to link up the words to help you remember) BP2: Did improve felt that I was helping my mental health. I felt that remembering a date came easier than usual. Theory of it could work. BP1: I would be tempted to get a book. BP2: Found counting aloud very easy. BP1: it definitely did stimulate the brain BP2: I enjoyed it BP2:The Stroop test kept you on your toes really tested you BP2: To a degree, I recognise the beneficial effect. Did feel an improvement in alertness has a similar effect to Transcendental meditation.	enjoyable. Differing attitudes to BT.
DMA	Problems experienced when using the CSTT relating to motor abilities. Finding it hard to turn pages or write calculations quickly.	Decline in Motor Abilities	BP1: I can answer the questions quicker in my head than my hand can write them. BP1: Found it frustrating my writing was too slow that frustrated me.	Participants physical ability differing from their mental ability.

Appendix AA: Older Adult Technology-based Completer group Interview

Introduction
Run through of script. P understands procedure, is in good humour. Reads and signs the consent form.

Moderator
1. Lead: Could you describe what you liked or disliked about the game?
It was a challenge, and I enjoyed it Had to do it every day certain extent enjoyed it.
Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses, calculations.
I liked the calculations mostly. Reading aloud never changed found it frustrating it didn't matter if I read it very slow or fast gave the same result. Brain age check was difficult (not every day)
Prompt: How did you find the word Memorization test?
Word memorization was found to be very difficult, tried to make up rhymes, couldn't master it.
Prompt: How did you find speaking aloud to the console?
Very easy. Stroop test was difficult, wouldn't register the colour blue was frustrating.
Prompt: Did using the game feel like homework?
Didn't find it a choir doing it for research,.
Prompt: Did using the game require diligence?
If I say ill do something I will

1. Participant enjoyed using the game "It was a challenge, and I enjoyed it". Participant liked the calculations, but was frustrated by the reading aloud game as she felt it was judged accurately ". Reading aloud never changed found it frustrating it didn't matter if I read it very slow or fast gave the same result". The Stroop test and the brain age check were both found to be difficult. With regard to diligence the participant didn't think completing the study required great diligence "Didn't find it a choir doing it for research".

Moderator
2. Lead. Do you feel you have benefited from using the game?
I do feel it helped my memory a bit. Yes but it is hard to be specific
Prompt. If so what kind of benefits do you feel you have gained?
Prompt: Did you show improvement in the calculations?
Towards the end there were improvements, much quicker than I was when I started.
Prompt. Alternatively do you feel you have not benefited from using the game?
Not in real life as no use for it. Definitely benefited
Prompt: In what way?
Prompt. Would you like to try the work book version of the game?
Would be tempted to try book.

2. Participant did feel benefits from the study but found it difficult to specify "I do feel it helped my memory a bit. Yes but it is hard to be specific". Improvements were felt in the calculations tasks. the participant stated that she would like to try using the book.

Moderator
3. Lead. How would you improve the game?

I would change the voice recognition. Memorizing words was very difficult. Once I got the hang of the brain age check tasks I enjoyed them.
Prompt: Would you change the screen size?
No screen size ok
Prompt: Would you improve the voice recognition?
Make the voice recognition more accurate. Reading aloud wasn't judged accurately enough.

3. As with other participants the participant stated the voice recognition was poor and should be improved and also that the reading aloud game was not judged accurately enough. "Make the voice recognition more accurate. Reading aloud wasn't judged accurately enough."

Moderator
4. Lead. How do you feel about *Brain Training*? Anything that helps memory is very important.
It's important for older people to use their brain.
Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?
Anything that makes you think is good. Yes further advancement needed
Prompt: Is it beneficial?
Prompt: In what way?
It makes you think

4. Participant believes that it is important for older people to use their brain and to stay mentally active. "It's important for older people to use their brain."
Moderator
5. Lead. Do you have any comments about the game?
Brain age check depending on the day would differ greatly was inconsistent. Sometimes distractions and tiredness changed the brain age.

Prompt: Were the instructions given good enough?
Prompt: What did you think of Dr Kawashima's tips?
Tips were repetitive and no use. Same thing over and over again the tips weren't very good.
Prompt: Was it easy to use?
No bother
5. Participant commented that it was easy for distractions or fatigue to interfere with the brain age check. The tips given in the game were found to be repetitive and of no use.

Moderator
6. Lead. Do you feel using the game will benefit you in everyday life in the future?
Yes did feel it beneficial, bought a Nintendo DS so as to continue with training still using on a daily basis and continued benefit.
Bought the consol and got friends interested in it.
Prompt: Do you feel any difference when, telling the time, remembering appointments?
Yes I think I benefited from it.
Prompt: If so do you still feel these benefits?

Reasons for diligence:

6. Benefit of *Brain Training* was felt by participant so much so the participant bought their own Nintendo ds to continue training.
Has experience with research and wanted to help. Saw an opportunity to help a researcher

with a study and didn't want to commit to smoothing and not follow through.

Notes

1. Participant enjoyed using the game "It was a challenge, and I enjoyed it". Participant liked the calculations, but was frustrated by the reading aloud game as she felt it was not judged accurately "reading aloud never changed found it frustrating it didn't matter if I read it very slow or fast gave the same result". The Stroop test and the brain age check were both found to be difficult. With regard to diligence the participant didn't think completing the study required great diligence "Didn't find it a choir doing it for research", "Saw an opportunity to help a researcher with a study and didn't want to commit to something and not follow through".

2. The participant did feel benefits from the study but found it difficult to specify "I do feel it helped my memory a bit. Yes but it is hard to be specific". Improvements were felt in the calculations tasks. The participant stated that she would like to try using the book.

3. As with other participants the participant stated the voice recognition was poor and should be improved and also that the reading aloud game was not judged accurately enough. "Make the voice recognition more accurate. Reading aloud wasn't judged accurately enough."

4. Participant believes that it is important for older people to use their brain and to stay mentally active. "It's important for older people to use their brain."

5. Participant commented that it was easy for distractions or fatigue to interfere with the brain age check "Brain age check depending on the day would differ greatly was inconsistent". The tips given in the game were found to be repetitive and of no use.

6. Benefit of *Brain Training* was felt by participant so much so that the participant bought their own Nintendo DS to continue training and recommended it to friends. The participant also inquired as to what other types of *Brain Training* games were available.

Phase1: Coding

Code	**Domain**
DIL	Diligence
RISI	Enjoyment
PB	Problems using Book
BT	*Brain Training*

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Diligence/Application	P used CSTT in order to help research, didn't require a huge amount of diligence	Diligence
Enjoyment	P enjoyed using the game	Enjoyment
Problems using CSTT	Problems with the reading aloud game and voice recognition. The Brain age check was found to vary greatly	Problems using game
Attitudes to BT	P felt that anything that helps the brain is important. Felt improvement but could not be specific	*Brain Training*

Phase 3: Emerging Themes

Code	Specific FIB	Quotes	Themes
Diligence/Application	P used CSTT in order to help research, didn't require a huge amount of diligence	Didn't find it a choir doing it for research. If I say ill do something I will	Participant does not see think a great amount of diligence is required
Enjoyment	P enjoyed using the game,	It was a challenge, and I enjoyed it I liked the calculations mostly. Yes did feel it beneficial, bought a Nintendo DS so as to continue with training still using on a daily basis and continued benefit. Bought the consol and got friends interested in it.	Participant enjoyed using the game. Notice positive benefits.

Problems using CSTT	Problems using CSTT related; Reading aloud, voice recognition in Stroop test, brain age check	"Reading aloud never changed found it frustrating it didn't matter if I read it very slow or fast gave the same result". The Stroop test and the brain age check were both found to be difficult. Brain age check depending on the day would differ greatly was inconsistent. Sometimes distractions and tiredness changed the brain age.	Participant finds the game in the large part interesting and enjoyable. Problems were found with the brain age check, voice recognition and the Reading aloud game.
Attitudes to BT	*Brain Training* found enjoyable and helpful overall.	"I do feel it helped my memory a bit. Yes but it is hard to be specific"	

Emerging Themes

The following themes were found on analysis of the Interview:

4. Participant enjoyed using the game
5. Using the game did not require a great amount of diligence.
6. Problems using the game
7. *Brain Training* seen as a positive cognitive aid

1. Participant enjoyed using the game

The Participant found the game beneficial and liked the *Brain Training* game. Some of the tasks such as were however found to be frustrating. The participant did not feel a great amount of diligence was required but did want to help the researcher. "Saw an opportunity to help a researcher with a study and didn't want to commit to something and not follow through"

2. Using the game did not require a great amount of diligence.

With regard to diligence the participant did not think completing the study required great diligence "Didn't find it a choir doing it for research". However the participant did comment that "If I say ill do something I will" and that she had experience with research these factors also contributed to the participant finishing the study. The participant later said: "I saw an opportunity to help a researcher with a study and didn't want to commit to something and not follow through" this quote shows that the participant is naturally diligent and follows through with commitments. As this participant enjoyed using the game and follows through with commitments it is not surprising that she did not drop out of the study.

3. Problems using the game.

A number of problems were experienced by the participant using the game similar to many the participants in Focus group A. As with other participants the participant stated the voice recognition was poor and should be improved and also that the reading aloud game was not judged accurately enough. "Make the voice recognition more accurate. Reading aloud wasn't judged accurately enough". The Stroop test and the brain age check were both found to be difficult. Participant commented that it was easy for distractions or fatigue to interfere with the brain age check "Brain age check depending on the day would differ greatly was inconsistent". The tips given in the game were found to be repetitive and of no use.

4. *Brain Training* seen as a positive cognitive aid

The participant believed that it is important for older people to use their brain and to stay mentally active. "It's important for older people to use their brain." Benefit of *Brain Training* was felt by the participant so much so that the participant bought their own Nintendo DS to continue training and also recommended it to friends. The participant also inquired as to what other types of *Brain Training* games were available. The participant did feel benefits from the study but found it difficult to specify "I do feel it helped my memory a bit. Yes but it is hard to be specific". Like many other participants obvious improvements were felt in the calculations tasks.

In Conclusion

The participant found the *Brain Training* game enjoyable and liked *Brain Training*. However a number of problems were noted such as the voice recognition, reading aloud game and the brain age check. With regard to *Brain Training* the participant felt that she had benefited from taking using the game but could not specify how. The participant did not think that using the game required great diligence but did comment that because it was for research she made an effort to finish the study.

Appendix AB: Older Adult Text-based Completer group Interview

Introduction

Run through of script. P understands procedure, is in good humour. Reads and signs the consent form.

Moderator

Lead: Could you describe what you liked or disliked about the book?
A. I didn't like using it at all.
Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 - 120, Stroop test?
A. Sitting down and self challenge, to me it wasn't logical. Liked the colours (Stroop test) Colours were good it made you think.
Prompt: How did you find the word Memorization test?
A. The words (word memorization) made me realize memory was bad, it woke me.
Prompt: Did using the book feel like homework?
A. Yes. It was a case of getting the time to sit down and do it.
Prompt: Did using the book require diligence?
A. Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it. It wasn't something I enjoyed doing.

1. Participant did not enjoy using the book "I didn't like using it at all". The participant felt like a child doing their homework with no great amount of diligence required "Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it" However through using the book the participant realized that their memory had deteriorated "the words (word memorization) made me realize memory was bad, it woke me". The participant saw this as a positive as she could try to improve her memory. Participant liked Stroop test similar to most participants interviewed.

Moderator

2. Lead. Do you feel you have benefited from using the book?
A. Yes was beneficial
Prompt. If so what kind of benefits do you feel you have gained?
A. made me aware of my short comings I'm not concentrating.
Prompt: Did you show improvement in the calculations?
A. Calculations went up and down was a bit better at the end but nothing major.
Prompt. Would you like to try the Nintendo DS Lite game version of the book?
A. Heard of the game for children. Wouldn't know how to use it doesn't think it would be for her generation. Doesn't see the benefit in general of BT.

Notes: The participant sees the benefit of *Brain Training* "yes was beneficial". After introspection it occurred to the participant that her mind had become lazy "made me aware of my short comings I'm not concentrating" and "made me aware that I am doing things more automatically then concentrating on them". The Nintendo DS game viewed as a device for children or for younger generations.

Moderator

3 Lead. How would you improve the book?
Make the content more interesting, give it a story. It is monotonous
Prompt. Some people commented that the book would not stay open did you find this?
Definitely doesn't stay open. Added to the time. Contunally having to squash down the book which takes up extra time.
Prompt: Would you prefer a ring binder?
Ring binder would be ideal. Had to keep concentrating to keep it open. It's the worst book ive ever come across for poping open.
Prompt: Did you use a stop watch to time yourself?
Yes kitchen timer.
Prompt: Would have liked an incorporated stopwatch?
Good idea to have a portable stop watch.

3. Participant comments that the book is monotonous and could be improved by being made more interesting perhaps utilizing a story. Similar to other participants the book was found to be too tightly bound leading to the book snapping shut when in use "definitely doesn't stay open. Continually having to squash down the book which takes up extra time". This led to the participant losing their place and taking more time to finish tasks. The idea of a ring binder being used to solve this problem was said to be "ideal". Also an incorporated stopwatch was said to also be a "good idea".

Moderator
4. Lead. How do you feel about *Brain Training*?
At first I thought it was crazy but now with hindsight I think it is very important.
Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?
Yes. In old age people switch off mentally. Need something that must be done everyday. Should be used within two years of retirement.
Prompt: Is it beneficial?
Prompt: In what way?

4. The participant initially thought *Brain Training* was "crazy" but with hindsight now thinks it is "very important". The participant also thought that *Brain Training* techniques are very important for older people

Moderator
5. Lead. Do you have any other comments about the book?
Prompt: Were the instructions given good enough?
The instructions given were good enough, book itself wasn't for me. Certain things that use brain for e.g. stocks and shares keeps me alert. If I didn't I would just watch TV or listen to the radio and drift off. Intellectual conversation et cetera engages the brain. Some people stay in bed all day. People would discover they need to keep their brain moving if they talked to someone like you.
Prompt: Was it easy to use?

Book was found to be easy to use with no problems with the instructions. Participant didn't'particularly like using the book "book itself wasn't for me". However as was

commented earlier, the participant thought that using the book was of positive benefit in order to stimulate the brain and commented that newly retired people could benefit from using it "People would discover they need to keep their brain moving if they talked to someone like you."

Moderator

6. Lead. Do you feel using the book will benefit you in everyday life in the future?
Prompt: Do you feel any difference when, telling the time, remembering appointments?
Prompt: If so do you still feel these benefits?
More alert stop being lazy. Should make things register and remember not just write them down. Now I realize it's important to register things in my mind as well as in the calendar.

Participant commented that she is more alert than before using the book. For instance when trying to remember appointments now she makes an effort to make a mental not instead of just noting it in a calander "Should make things register and remember not just write them down. Now I realize it's important to register things in my mind as well as in the calendar."

Overall the book

Overall theme: book gave awareness to participant that concentrating/paying attention to a task is good for the brain. However the book was monotonous and boring a more interesting alternative would have been better. Might be good for other people but not for me.

Participant quote: "Sitting down and doing it every day is a bit monotonous. The book achieves what it's meant to achieve but it does it in a boring way. The game would be for the next generation not my generation."

Notes

1. Participant did not enjoy using the book "I didn't like using it at all". The participant felt like a child doing their homework with no great amount of diligence required "Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it". However through using the book the participant realized that their memory had deteriorated "the words (word memorization) made me realize memory was bad, it woke me". The participant saw this as a positive as she could try to improve her memory. Participant liked Strop test similar to most participants interviewed.

2. The participant sees the benefit of *Brain Training* "yes was beneficial". After introspection it occurred to the participant that her mind had become lazy "made me aware of my short comings I'm not concentrating" and "made me aware that I am doing things more automatically then concentrating on them". The Nintendo DS game viewed as a device for children or for younger generations.

3. Participant comments that the book is monotonous and could be improved by being made more interesting perhaps utilizing a story. Similar to other participants the book was found to be too tightly bound leading to the book snapping shut when in use "definitely doesn't stay open. Continually having to squash down the book which takes up extra time". This led to the participant losing their place and taking more time to finish tasks. The idea of a ring binder being used to solve this problem was said to be "ideal". Also an incorporated stopwatch was said to also be a "good idea".

4. The participant initially thought *Brain Training* was "crazy" but with hindsight now thinks it is "very important". The participant also thought that *Brain Training* techniques are very important for older people.

5. Book was found to be easy to use with no problems with the instructions. Participant didn't particularly like using the book "book itself wasn't for me". However as was commented earlier, the participant thought that using the book was of positive benefit in order to stimulate the brain and commented that newly retired people could benefit from using it "People would discover they need to keep their brain moving if they talked to someone like you."

6. Participant commented that she is more alert than before using the book. For instance when trying to remember appointments now she makes an effort to make a mental not instead of just noting it in a calendar "Should make things register and remember not just write them down. Now I realize it's important to register things in my mind as well as in the calendar."

Emerging themes

Book gave awareness to participant that concentrating/paying attention to a task is good for the brain. However the book was monotonous and boring a more interesting alternative would have been better. Might be good for other people but not for me. This is evidenced by the following quote:

"Sitting down and doing it every day is a bit monotonous. The book achieves what it's meant to achieve but it does it in a boring way. The game would be for the next generation not my generation."

Phase1: Coding

Code	Domain
DIL	Diligence
EMT	Enjoyment
PB	Problems using Book
BT	*Brain Training*
Mem	Memory

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Diligence/Application	P used CSTT in order to help research, didn't require a huge amount of diligence	Diligence
Enjoyment	P didn't enjoy using the game, look forward to it something she had to do	Enjoyment
Problems using CSTT	Problems using CSTT related; problems with turning pages, timing, colours. Thought the book monotonous. Liked the Stroop test.	Problems using book
Attitudes to BT	Like/ BT, felt they worked/didn't work. Attitude to *Brain Training*. Good idea for older people	*Brain Training*
Memory/Concentration	P felt it important to concentrate on the BT tasks. That older people can switch off and become lazy if they let themselves.	Memory

Phase 3: Emerging Themes

Code	Specific FIB	Quotes	Themes

Diligence/Application	P used CSTT in order to help research, didn't require a huge amount of diligence	"Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it"	Participant does not see think a great amount of diligence is required
Enjoyment	P didn't enjoy using the game, look forward to it something she had to do	"I didn't like using it at all" "didn't look forward to or enjoy it"	Participant didn't enjoy using the book but did notice positive benefits.
Problems using CSTT	Problems using CSTT related; problems with turning pages, timing, colours. Thought the book monotonous. Liked the Stroop test.	"Definitely doesn't stay open. Continually having to squash down the book which takes up extra time". "Sitting down and doing it every day is a bit monotonous. The book achieves what it's meant to achieve but it does it in a boring way."	Participant finds the book monotonous. Book won't stay open properly.
Attitudes to BT	Like/ BT, felt they worked/didn't work. Attitude to *Brain Training*. Good idea for older people	At first I thought it was crazy but now with hindsight I think it is very important. Yes. In old age people switch off mentally. Need something that must be done every day. Should be used within two years of retirement. Now I realize it's important to register things in my mind as well as in the calendar." "Should make things register and remember not just write them down. "	*Brain Training* is seen as of positive benefit to older people. BT gives the participant something to concentrate on, helping to keep the mind active.

Themes

The following themes were found on analysis of the Interview:

1. Participant does not think a great amount of diligence is required
2. Participant didn't enjoy using the book but did notice positive benefits.
3. Number of problems with book
4. *Brain Training* is seen as being a positive benefit

1. Participant does not think a great amount of diligence is required

During the interview the participant commented that using the book each day did not require great diligence "Took no application or diligence, like a child doing their homework didn't look forward to or enjoy it"

2. Participant didn't enjoy using the book but did notice positive benefits.

Participant did not enjoy using the book "I didn't like using it at all". However through using the book the participant realized that their memory had deteriorated "the words (word memorization) made me realize memory was bad, it woke me". The participant saw this as a positive as she could try to improve her memory. Participant liked Stroop test similar to most participants interviewed.

3. Number of problems with book

The participant commented that the book is monotonous and could be improved by being made more interesting perhaps utilizing a story. Similar to other participants the book was found to be too tightly bound leading to the book snapping shut when in use "definitely doesn't stay open" and "continually having to squash down the book which takes up extra time". This led to the participant losing their place and taking more time to finish tasks. The idea of a ring binder being used to solve this problem was said to be "ideal". Also an incorporated stopwatch was said to also be a "good idea". Book was found to be easy to use with no problems with the instructions. Participant didn't particularly like using the book "book itself wasn't for me".

4. *Brain Training* is seen as being a positive benefit

The participant initially thought *Brain Training* was "crazy" but with hindsight now thinks it is "very important". The participant also thought that *Brain Training* techniques are very important for older people. However as was commented earlier, the participant thought that using the book was of positive benefit in order to stimulate the brain and commented that newly retired people could benefit from using it "People would discover they need to keep their brain moving if they talked to someone like you." Participant commented that she is more alert than before using the book. For instance when trying to remember appointments now she makes an effort to make a mental not instead of just noting it in a calendar "Should make things register and remember not just write them down. Now I realize it's important to register things in my mind as well as in the calendar."

In conclusion

The book helped the participant become aware that concentrating and paying attention to a task is good for the brain. However the book was monotonous and boring and more interesting alternative would have been better. This is evidenced by the following quote: "Sitting down and doing it every day is a bit monotonous. The book achieves what it's meant to achieve but it does it in a boring way. The game would be for the next generation not my generation."

Appendix AC: Technological Intervention Student Focus Groups

Focus Group Notes

Focus Group C1: Game

7 participants – 4 Females, 3 Males.

Qs 1: Lead: Could you describe what you liked or disliked about the game?

GM2 – I like the fun aspect, games are easy to follow and enjoyable. Lots of instruction given easy to follow. ENJ

GM3 – The graphic system allows you to see how well you are doing. Pos

GF3 – Like trying to reduce your times. ENJ Pos

GM1 – The goals make you think about what's coming next, like incentives. Unlocking games as you go along. Pos

Prompt: What specific items of the game did you like e.g. speaking aloud, reading clock faces, counting people going into houses.

GF1 – Didn't like the counting part, it's boring. Speed counting game PRO

GF2 – Voice recognition is bad - it didn't work well. (stroop test) PRO

GF3 – Didn't use the speaking option. PRO

GF1 – The answers you wrote were inputted differently – G,K,Y were unrecognised. Word memorization was ruined. PRO

GF2 – Picked the 3 best (options). Enjoyed connect maze game.

GM2 – Found it annoying when your hand was covering the 'link' you're going to. (participants all in good humour) PRO

Notes: Participants in good humour. Participants liked game fun aspects. Unlocking games viewed as good incentives. Participants didn't like speed counting game, voice recognition was bad, word memorization was ruined by this. Like connect maze.

What time of the day would you use it?

Times

GM2 – Either early or very late.

GM3 – A lot better in the mornings.

GF2 & GF3 – Usually the evenings.

GM2 – Too tired in the evenings.

Qs 2: Lead. Do you feel you have benefited from using the game?

GM1 – You don't feel any great benefits from the game. You just get better at recognising them. Att

GF2 – You can't apply to everyday life scenarios. Att

Prompt. If so what kind of benefits do you feel you have gained?

GM2 – An increase in knowledge base but not memory, you wouldn't have benefited. ATT

Prompt. Alternatively do you feel you have not benefited from using the game?

GM2 – No there is a benefit but not as great as it could be. Att

GM1 – (An experience of Research Methods).

Prompt. Would you like to try the work book version of the game?

All – Wouldn't like to try the workbook version, would all pick the DS again. Att

Notes: Participants do not think they have benefited greatly from using the game. Participants would not like to try book.

Qs3: Lead. How do you feel about *Brain Training*?

GM1 – Liked the idea of it, but it got boring half-way through. Had to force myself to do the tasks so my score got worse. dil

GF3 – The novelty wore off.dil

GM2 – It was a task rather than a want. Something we have to do vs. someone buying it for themselves. dil

GF3 – Reading aloud game got boring PRO

GM3 – The game felt broken at times, reading too fast. Misreading the user a lot. PRO

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

GF1 – Games like scrabble more fun but less obvious what they are intending to do. (nb *Brain Training*) Att

GM2 – Older generation might be put off by the technology. (Attitudes toward older generation) ATOU

Prompt: Is it beneficial?

GM2 – It's beneficial, keeping the brain working and active. ENJ Att

GF1 – I would like more feedback on how it calculated your tests; e.g. the Stroop test. Immediate feedback on each one as you did it. PRO

GM1 – Psychology students used to testing methods and so will look deeper into the results, a need for further investigation.

All – Brain-age all was all over the place and went up and down. (Brain age changes too easily) PRO

GF1 – The character was annoying; the tips had already been seen. PRO

GM2 – May disregard new tips as you get so used to deleting them all the time. PRO

GM3 – It's off-putting, should be an option to turn him off. Kawashima character is like the Microsoft paper clip. – (good quote) PRO

Notes: participants got bored with training. Game felt very broken at times. Brain age changed too easily. Tips and dr kawashima character were found frustrating "Kawashima character is like the Microsoft paper clip"

Qs 4: Lead. Do you feel using the game will benefit you in everyday life in the future?

GM3 – No, not really.

GF2 – It's hard to know if your memory improves and hard to know if this is a result of the game. Hard to quantify. Att

GM2 – It depends on how good your memory has been to begin with. Att

GF1 – It was enjoyable making stories to try remembering the words. Different ways of remembering. ENJ

All – Stories worked best.

GM2 – Grouping also worked well.

GM3 – Remembered the ones you couldn't see on the pad.

GM1 – Organisationally I was better at the start, but this soon fell off.

GM3 – Forgetting to play the game obviously didn't help.

Prompt: Do you feel any difference when, telling the time, remembering appointments?

GM2 – It's quite ironic forgetting to actually play a game associated with memory.

GM2 – I didn't play Sudoku, although I normally play it.

Notes: Participants don't think there will be future benefits from training. Did like trying new methods of remembering words. Participants forgot to do *Brain Training*.

Qs 5: Lead. What did you like/dislike about the study?

Prompt. Is there any way in which the researcher could have made the study easier for you?
GM2 – Some way of reminding you to play the game would have been good.
GF3 – A group e-mail would have worked.
GM2 – No problem playing the game, just remembering to actually play the game.
GF3 – Reminders from researcher would have been helpful.

Notes: Participants asked for email reminders to play game. They shouldn't need them!

Qs 6: Lead. Did other people e.g. friend, spouse comment about you progress?

GF1 – My boyfriend asked my scores regularly.
GM2 – Friends slagged me over playing the DS as part of college work.
GM2 – My family had brought a DS because of the brain-training game initially. They are well-used to the idea of the game. ATOU

Notes:
Participants in good humour. Participants liked game fun aspects. Unlocking games viewed as good incentives. Participants didn't like speed counting game, voice recognition was bad, word memorization was ruined by this. Like connect maze.

What time of the day would you use it?
Times
GM2 – Either early or very late.
GM3 – A lot better in the mornings.
GF2 & GF3 – Usually the evenings.
GM2 – Too tired in the evenings.

Q1. Participants do not think they have benefited greatly from using the game. Participants would not like to try book.

Overall much more positive feedback then the book group

Liked

- Fun, easy to follow, enjoyable,
- Graphic system,
- Reducing times,
- Goals/incentives, unlocking new games

Didn't like

- Speed counting – boring
- Voice recognition
- Word memorization

Q2. Participants do not feel they have benefited greatly form using the game. No overall improvements in cognition. Participants would not like to try using the book version.

Q3. Participants got bored with training after a few weeks found it hard to keep up (use diligently). Game felt very broken at times. Games like scrabble more fun less obvious what it's trying to do. Participants commented that older participants can be put off by technology. Brain age changed too easily. Tips and Dr Kawashima character were found frustrating "Kawashima character is like the Microsoft paper clip"

Q4

Participants don't think there will be future benefits from training. However participants did like trying new methods of remembering words.

Q5. Participants forgot to do *Brain Training*. Cant remember to do the *Brain Training* therefore *Brain Training* isn't working?

Participants asked for email reminders to play game. They shouldn't need them!

Q6. Older members of family were well used to the idea of *Brain Training*.

Phase 1: Coding

Code	**Domain**
DIL	Diligence
ENJ	Enjoyment
PB	Problems using Game
PA	Positive aspects of the game
BT	*Brain Training*
ATOU	Attitude to older users

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Diligence/Application	P found the game difficult to keep up on a daily basis	Diligence
Enjoyment	Participants enjoyed using the game to a certain degree	Enjoyment
Problems using CSTT	Problems similar to older adults using the game	Problems using game
Positive aspects of game	P comented on a number of aspects they liked	Enjoyable aspects of the game
Attitudes to BT	*Brain Training* viewed as beneficial in the short term.	*Brain Training* attitudes
Attitudes to older users	Mixed attitudes, easier for older people to use as they would be more interested in it.	Attitude to older users

Code	Specific FIB	Quotes	Themes
Diligence/Application	Problems using book everyday. Participants found the game boring and became a task rather than a want	Liked the idea of it, but it got boring half-way through. Had to force myself to do the tasks so my score got worse. The novelty wore off It was a task rather than a want. Something we have to	Participants found the game hard to use continually after a few weeks.

		do versus someone buying it for themselves.	
Enjoyment	Participants found many aspects of the game fun and enjoyable.	I like the fun aspect, games are easy to follow and enjoyable. Lots of instruction given easy to follow. Like trying to reduce your times. It's beneficial, keeping the brain working and active The goals make you think about what's coming next, like incentives. Unlocking games as you along.	Participants enjoyed many aspects of the game.
Problems using CSTT	Problems using the game were similar to problems experienced by older users. Speed counting, voice recognition, tips.	Didn't like the counting part, it's boring. (Speed counting) Voice recognition is bad - it didn't work well. (stroop test) Didn't use the speaking option. The answers you wrote were inputted differently – G,K,Y were unrecognised. Word memorization was ruined. Found it annoying when your hand was covering the 'link' you're going to. (participants all in good humour) Reading aloud game got boring The game felt broken at times, reading too fast. Misreading the user a lot. The character was annoying; the tips had already been seen. May disregard new tips as you get so used to deleting them all the time.	A number of problems were discovered using the game.

		It's off-putting, should be an option to turn him off. Kawashima character is like the Microsoft paper clip. – (good quote) I would like more feedback on how it calculated your tests; e.g. the Stroop test. Immediate feedback on each one as you did it.	
Attitudes to BT	Participants feel that *Brain Training* will not benefit them in the long term. Feel that it is beneficial but not sure how quantifiable this is.	Games like scrabble more fun but less obvious what they are intending to do. You don't feel any great benefits from the game. You just get better at recognising them. You can't apply to everyday life scenarios. An increase in knowledge base but not memory, you wouldn't have benefited. No there is a benefit but not as great as it could be Wouldn't like to try the workbook version, would all pick the DS again. It's beneficial, keeping the brain working and active. It depends on how good your memory has been to begin with It's hard to know if your memory improves and hard to know if this is a result of the game. Hard to quantify.	Participants are sceptical of the long term benefits of BT.
Positive attributes of the *Brain Training* game.	Participants liked many aspects of the game. It was fun,easy to follow, liked the interface	I like the fun aspect, games are easy to follow and enjoyable. Lots of instruction given easy to follow. GM3 – The graphic system allows you to see how well	Particpnats commented about a number of positive aspects of the game.

	(graphic system). Liked the incentivises i.e. to unlock more games	you are doing. GF3 – Like trying to reduce your times. GM1 – The goals make you think about what's coming next, like incentives. Unlocking games as you along.	
Attitudes to older users	Some commented that older users might be put off by technology others suggested that older relatives are used to it.	Older generation might be put off by the technology. My family had brought a DS because of the brain-training game initially. They are well-used to the idea of the game.	Mixed attitudes to older users.

Appendix AD: Text-based intervention Student Focus Group

Focus Group C2: Book. Date: 04/12/2009

7 Participants - 6 Males, 1 Female.

Qs 1: Lead: Could you describe what you liked or disliked about the book?

BM2 – Pointless and difficult to keep up on a daily basis, it's repetitive. So easy to forget about. DIL ENJ

Prompt: Did using the book feel like homework?

BM1 – Even though we are the participants, it's still not voluntary.

Prompt: What specific items of the game did you like e.g. arithmetic, counting 1 - 120, stroop test?

BM6 – Satisfying to beat your score. ENJ

BM1 – Good to practice using your brain. BT

Prompt: Did you use the graphs at the back of the book?

BM6 – No as we had to keep a log which was the same thing as the graphs.

Notes: Differing opinions about the book some negative : "Pointless and difficult to keep up on a daily basis, it's repetitive" some positive: "Good to practice using your brain"

Qs 2: Lead. Do you feel you have benefited from using the book?

BM2 – Not beneficial. The difference in scores makes you feel sharper, I found myself butting in on people to solve their math problems. BT

BM6 – The game is more competitive than the book. Not entertaining but more engaging. A game would be more entertaining than the book. ENJ

BM2 – I feel indifferent. Maintaining is necessary though.

BF1 – The times of the day matter significantly.

BM1 – Before bedtime makes everything sink in better.

BM4 – Tiredness affects results at night.

Prompt. Do you feel using the book will benefit you in everyday life in the future?

BM2 – I'd use the game but not the book. BT

BM5 – There would be an obvious difference if I kept it up. DIL

BM2 – If you had a stimulated day, the differences may not be so apparent.

Prompt: Is it beneficial?

All – The book is beneficial. BT

BM6 – I improved in every part – don't know how you would apply that to real-life. The lifestyle of a student is less routine. BT

BM5 – I have become more automatic with equations in general. BT

BM6 – You develop your own ways of memorising things, e.g. word related to each other. BT

BM3 – Think of pictures/stories with words or words that rhyme.

BM6 – Words in groups of threes.

BM1 – Use tricks for remembering from primary, secondary school. BT

BM6 – Good to be reminded.

BM5 – you assume you know it until you need to recall it quickly.

Notes: Participants improved with calculations. But not sure if there were more long lasting improvements. Different ways of remembering words. The book wasn't enterataining.

Qs 3: Lead. How do you feel about *Brain Training*?

BM3 – Good, there was self-improvement.

BM2 – Get good at tasks individually but difficult to apply to others. (doesn't apply globally). BT

BF1 – They're the same but reversed. Have you actually learned the answers or is your brain working to solve the answers. Do you just recognise the questions quicker? BT

Prompt. Do you think similar *Brain Training* techniques are a good idea for older people?

BM1 – Similar to muscles being built up in sport.

BM2 – Techniques apply more to older people. ATOU

BM1 – In the 60's and 70's it is supposed to reduce Alzheimer's. ATOU

BM5- Exercising the mind is good.

BM6 – Advertising – young people ask what are you doing that for? Older people are more enthusiastic about it. ATOU

Prompt. Is there a social aspect to it?

All – There are no social aspects to the book, except for the comparison of scores.

Prompt. Does the book play on fears of older people?

BM5- Appealing to the worries of older people (fears).

BM6 – Scare tactics used through statistics.

BF1 – Adverts use actors for *Brain Training* saying how great it is. Ads show Patrick Stewart having a good time to show how good it is. ATOU

Notes: like the idea of *Brain Training* but think it applies more to older people. There were improvements but you can't be sure if the improvements in calculations are improvements or just learnt off by rote.

Qs 4: Lead. Did other people e.g. friend, spouse comment about you progress?

All – Nobody commented on it.

BF1 – Kept it to myself. Friends asked why using the book and not the game. More than 1 book? When finished you don't want to start the same book all over again. I didn't even know there was a book before the study.

BM1 – Books appeal to older users. ATOU

BM5 – Frustration with technology – older users, throws it away. Dad tried it ATOU

BF1 – Appeals to older adults who do crosswords and Sudoku puzzles. ATOU

Prompt: Do you think older adults would want to use one *Brain Training* tool more?

BM1 – It would vary who would want to use the book or the game.

BM6 – Some adults big into learning new technologies – grandparents are very interested opposed to people of the same age as myself. ATOU

Prompt. Any other comments on the book?

BM1 – Quite off-putting if you miss a few days.

BM5 – Takes a lot of will to do it every day. (diligence/application)

BM1 – College students – lack of routine might be a problem. (routine)

BM6 – College work came first, so am more tired when doing it after this.

BM5 – If it becomes a chore, you put it off even though it only takes 5 minutes. ENJ

Notes: Attitudes to older adults. *Brain Training* viewed as something for older generations Diligence needed to keep it up. It became a chore. DIL

Qs 5: Lead. What did you like/dislike about the study?

BM2 – Might have helped to have been reminded e.g. e-mail. A requirement to e-mail your scores to the researcher might have helped just to keep it in your head. (this comment shows that it was easy to forget about)

BM1 – Results of research in e-mails with positive effects would increase motivation.

Prompt. Is there any way in which the researcher could have made the study easier for you?

BM1 – During tests, noise from others effects concentration; quieter rooms may help. Although noise is representative of the real-world where you would normally solve puzzles.

BM1 – I liked the Raven's test, is this wrong? (N.B. Attitude)

BM2 – Interested to get results from that.

BM5 – I think I would have done better than the 1st time.

BM2 – As you went through the 1st one, you became better at identifying patterns, how to look for them and so on.

BM1 – Do we get feedback from the overall results? (Inquisitive behaviour).

Notes:

Participants would have liked email reminders. Some participants liked memory tests.

Notes

Differing opinions about the book some negative : "Pointless and difficult to keep up on a daily basis, it's repetitive" some positive: "Good to practice using your brain". Positive comments are more to do with using the brain not the specific book.

Participants improved with calculations. But not sure if there were more long lasting improvements.

Positive: Different ways of remembering words.
Negative: The book wasn't entertaining.

Like the idea of *Brain Training* but think it applies more to older people. There were improvements but you can't be sure if the improvements in calculations are improvements or just learnt off by rote.

Attitudes to older adults: *Brain Training* viewed as something for older generations Diligence (will) needed to keep it up. It became a chore.
Participants would have liked email reminders. Some participants liked memory tests.

Phase 1: Coding

Code	**Domain**
DIL	Diligence
ENJ	Enjoyment
PB	Problems using Book
BT	*Brain Training*
ATOU	Attitude to older users

Phase 2: Coding guide using specific FIBs (Factors Influencing Behaviour)

Code	Specific FIB	FIB Domain
Diligence/Application	P found the book difficult to keep up on a daily basis	Diligence

Enjoyment	Participants did not enjoy using the book	Enjoyment
Problems using CSTT	P didn't comment on problems using the book unlike older adults	Problems using Book
Attitudes to BT	*Brain Training* viewed as a positive	*Brain Training*
Attitudes to older people	P see the training tool as the remit of older people	Attitude to older users

Phase 3: Emerging Themes

Code	Specific FIB	Quotes	Themes
Diligence/Application	Problems using book everyday	Pointless and difficult to keep up on a daily basis, it's repetitive. So easy to forget about. There would be an obvious difference if I kept it up. Diligence needed to keep it up Takes a lot of will to do it every day	Participants found the book difficult to use continually due to repetitive nature of the book
Enjoyment	No enjoyment: pointless,repetitive, a chore	Pointless and difficult to keep up on a daily basis, it's repetitive Satisfying to beat your score If it becomes a chore, you put it off even though it only takes 5 minutes.	Participants didn't enjoy using the book
Problems using CSTT	Times of day,	– The times of the day matter significantly. – Before bedtime makes everything sink in better. – Tiredness affects results at night.	No problems using the book noted. Problems noted were related to the time of day using the book
Attitudes to BT	Differeing attitudes: benenfits of *Brain*	-Good to practice using your brain. -The difference in scores	Participants agreed that trying to train

	Training versus skeptisms about actual improvements overall.	makes you feel sharper, I found myself butting in on people to solve their math problems -I'd use the game but not the book. -The book is beneficial -I improved in every part – don't know how you would apply that to real-life. The lifestyle of a student is less routine -I have become more automatic with equations in general -You develop your own ways of memorising things, e.g. word related to each other – Use tricks for remembering from primary, secondary school – Get good at tasks individually but difficult to apply to others. (doesn't apply globally). - Have you actually learned the answers or is your brain working to solve the answers. Do you just recognise the questions quicker	your brain is beneficial. Participants commented that they would feel an improvement in calculation tasks. However participants could not agree if this applied outside of the calculations tasks i.e.if there were more global improvements. Participants agreed that a number of memorization strategies were used during the word memorization tasks.
Attitudes to older people	Mixed attitudes towards elderly. Book doesn't seem to apply to younger users. Applies to older users however some older adults are big into learning new	-Some adults big into learning new technologies – grandparents are very interested opposed to people of the same age as myself. -Books appeal to older users. -Frustration with technology – older users, throws it away. Dad tried it	Mixed attitudes to older people. Some interesting insights. *Brain Training* is seen to apply to older people more so than younger. Book applies to older

	technologies.	– Appeals to older adults who do crosswords and Sudoku puzzles. – Adverts use actors for *Brain Training* saying how great it is. Ads show Patrick Stewart having a good time to show how good it is. -Young people ask what are you doing that for? Older people are more enthusiastic about it. -Techniques apply more to older people. – In the 60's and 70's it is supposed to reduce Alzheimer's.	users. Adverts. Not all participants think that older users want to use the book.